KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST)

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

FACULTY OF BIOSCIENCES

EFFECT OF DRYING METHODS ON NUTRITIONAL COMPOSITION AND SENSORY QUALITIES OF DEHYDRATED SLICED MANGO (*Mangifera indica L.*) PULP

A Thesis Submitted to the Board of Postgraduate Studies (KNUST) in Partial Fulfillment of Requirement for the Award of the

Master of Science (M.Sc.) Degree in Food Science and Technology

By

GODSON TETTEY

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ABSTRACT

Fresh, ripe and firm mango varieties (Keitt and Kent) were obtained from a commercial farm in Somanya and used for the studies. The research was carried out on mango slices to study the effects of some pretreatment methods and drying using the solar and gas drying methods. The effects of packaging types and storage time on the sensory and nutritional qualities of solar and gas dried mango fruits were studied. The study showed that pretreatment significantly ($p<0.05$) affected all parameters with the exception of crude fibre. Certain nutritional and sensory properties were significantly maintained as compared to control samples (no pretreatment) for the two mango varieties studied. Though all pretreatments had significant effect ($p<0.05$) in maintaining nutritional and sensory qualities as compared to control samples, potassium metabisulphite pretreatment was more preferred for solar drying of the two mango varieties. Gas dried mango fruits had significant effect ($p<0.05$) in maintaining nutritional and sensory qualities as compared to the solar dried mango fruits with no pretreatment for both mango varieties and the gas dried samples were more preferred to the solar dried ones. The packaging material and storage time significantly ($p<0.05$) affected the moisture, microbial load, vitamin C and pro-vitamin A during storage. High density polyethlene and polypropylene packs were suitable for storing both sulphited solar dried and gas dried mango fruits since there were no significant differences ($p>0.05$) in the parameters monitored. No significant differences ($p>0.05$) were recorded between the two mango varieties used on all the nutritional and sensory attributes monitored with the exception of pro-vitamin A and vitamin C contents for solar dried pretreated mango fruits slices.

TABLE OF CONTENTS

CHAPTER THREE

LIST OF FIGURES

LIST OF TABLES

DECLARATION

I hereby declare that this submission is my own work towards the Master of Science and that to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University, except where due acknowledgement in the text.

GODSON TETTEH

……..	……..	……..
(Student's Name)	Signature	Date

Supervisor's Name	……..	……..
(Prof. J. H. Oldham)	Signature	Date

Certified by:

Dr. I. Oduro	……..	……..
(Head of Department)	Signature	Date

1.0 INTRODUCTION

Fruits and vegetables represent an important area of world agriculture production and form an indispensable part of human diet in Ghana. Their nutritional value that provide essential amounts of minerals, vitamins, dietary fibre, protein and calories are well recognized and documented (Salunke *et al*., 1991). However, many fruits and vegetables are usually in short supply especially during the dry seasons and because the indigenous ones grow abundantly in the rainy season are mostly wasted, due to lack of effective processing and preservation methods.

In Ghana, fruits and vegetables are abundantly produced during peak seasons but due to lack of proper storage and preservation facilities, the market becomes overstocked during such seasons and a large proportion get rotten before reaching the final consumer. Alzamora *et al*., (2000) has reported that about 30-50% of fruits and vegetables harvested in developing countries including Ghana are never consumed due to spoilage during transportation, storage and processing.

The reduction of post-harvest food losses is a complementary means for increasing food production. This draws its importance not only from a moral obligation to avoid waste, but also because the cost of preventing food losses in general is less than producing a similar amount of food of the same quality.

Six commercial varieties of mangoes are currently produced in the country. They are Kent, Keitt, Haden, Tommy Atkins, Palmer and Zill.

According to experts, 85% of the fruit under cultivation is of the Keitt variety (Daily Graphic Vol. 339, Tuesday 21st February, 2006).

Mango cultivation represents one area within the horticultural sector which if well developed and provided with the necessary logistics and support can easily become a major foreign exchange earner. This is because the country has the natural conditions that can position the crop as a top export product.

According to the experts in the industry, Ghana is one of the few countries in the world with two mango seasons and with the right practices both seasons can yield fruits for the international market (Daily Graphic Vol. 399, February 21st 2006).

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In Ghana, mango grows very well in both transitional and the savannah belt due to the favourable climatic conditions. However, the southern belt of the country is the main mango producing area with a total of 5,000 acres under cultivation.

The potential for the northern part of the country to play a vital and leading role in the mango industry is very paramount due to its favourable climatic conditions. In recent times, a total of 2,000 out growers have been financial and technically supported to access quality mango seedlings to establish and expand the mango plantation in Northern Ghana. It is expected that these interventions would go a long way to increase mango production in the north and Ghana as a whole.

Mango (*Mangifera indica L.*) is one of the favoured fruits in the tropical and subtropical regions. It has an excellent flavour, attractive fragrance, delicious taste and high nutritional value that have made it one of the best fruits (Pal, 1998). The fruits are very much relished for their succulent, exotic flavour and delicious taste

Mangoes are rich source of beta - carotene, a provitamin A carotenoid that is converted to vitamin A in the body. Vitamin A is an essential nutrient required for normal growth, reproduction, vision and immune health, in less developed countries. Mangoes can provide this much needed vitamin to prevent deficiencies that often develop during the off-season.

The consumption of vitamin A is low among the Ghanaian population and especially in the northern part of country in children under 5 years of age. Inadequate intake of vitamin A over a long period can result in vitamin A deficiency. Vitamin A deficiency is a major public health problem in Ghana (Benamba, 2005).

Mangoes are also an important source of the essential nutrient vitamin C. Vitamin C is necessary for normal collagen breakdown and the disorder scurvy. It also serves as a cofactor for some enzymes in the body and is a powerful water soluble antioxidant that prevents free radical damage to cells.

The northern part of the country has five months of rainy season usually from May-September. Inhabitants in these areas derive their essential vitamins from green leafy vegetables which are usually scarce during the dry season. At the same period the leafy vegetables are scarce, the mango fruits are not in season.

In Ghana, mango fruits are primarily consumed in the fresh state usually as dessert and sometimes as a fruit drink or juice. Dried mangoes fruits are promising and healthy snack products for regional as well as export market. Dried fruits are tasty, nutritious, lightweight, easy-to-prepare, and easy-to-store and use.
Due to high post harvest losses of fruits and vegetables, there is the need to process and preserve perishable fruits during bumper harvest to make these fruits available throughout the year in a value added form

Dehydrated mango fruits slices could be processed from the glut by individuals or farmer-groups to address the vitamin A and C problems experienced especially in these areas in the north and the entire country as a whole.

Fruits and vegetables contain several enzymes such as polyphenol oxidase which catalyse the oxidation of phenolic compounds to brown colour on their cut surfaces (Whitaker and Lee, 1995; Sapers and Miller, 1992, 1993, 1995). Peeling and cutting are the key steps in the preparation of minimally processed vegetable and fruits. During these operations cell membranes are broken and appropriate substrates come into contact with oxidizing enzymes. In the presence of oxygen, rapid browning occurs due to enzymatic oxidation of phenols to orthoquinones, which rapidly polymize to form brown or black pigments, such as melanins (O'Beirnne; 1995, Sapers and Douglas, 1987).
Pre-treatment before drying helps in inhibiting browning reactions and maintaining sensory and nutritional properties of fruits and vegetables.

Drying is an ancient method of preservation of food. It consists of taking out a large part of the water contained in a product in order to reduce considerably the reactions which lead to the product's deterioration. The water is eliminated by evaporation into the surrounding air, or in other cases freeze drying sublimation under vacuum to yield

a dried product. This occurs under conditions of temperature and pressure (Massa and LeMaguer, 1980).

Drying has to occur rapidly (to avoid the product going mouldy) but not too rapidly (a crust could then form on the surface) or at too high a temperature (the product spoils, or blackens).

Drying extends the shelf-life of biological materials through the reduction of water activity; reduce weight and bulk of the material and convenience for consumers. Textural changes, loss of vitamins and other essential nutrients through various reactions, colour changes associated with browning reactions, non uniformity in slice thickness and mould growth are some of the major problems associated with fruits and vegetables during and after drying (Salunkhe *et al*., 1991). To overcome some of these problems, pre-treatments are applied to the fruits and vegetable before drying and the dried products packaged well in a good material.

Technologies used in dry processing and preservation of fruits are numerous and varied ranging from simple to sophisticated and complex technologies. Mango fruits are dried through different methods of drying systems. Some fruits are dried by vacuum air drying, direct solar drying, solar drying, microwave drying, freeze drying and osmotic drying to mention a few. These dryer types have their cost and advantages and how they impact on the nutritional and sensory qualities of dehydrated fruits.

Solar dryers are specialized devices that control the drying process and protect agricultural produce from damage by insects, dusts and rain. In comparison to drying product in the open, solar dryers generate higher temperatures and lower relative humidity, and increase flow of air across the produce, resulting in shorter drying period, lower product moisture content and reduce spoilage during the drying process.

Solar dryers come in various forms and sophistication. The basic principle is that air is heated in a collector by the green house effect. The hot air then dries the product in the drying chamber. Depending on the construction, both collector and drying chamber may be combined or separated.

Solar driers, however, are not always the most effective means of producing high quality dried fruit because in many places of the tropics, the rainy season lasts averagely five months annually, during which time solar driers are non-operational.

Technologies that make use of fuel (gas) powered driers such as butane/liquefied petroleum gas have gained prominence in the food processing industry.

The fuel (gas) powered driers gives increased control over drying conditions and produces a higher quality product. It is operational all year round, and produces a higher rate of drying than solar drier.
The improved solar and the gas cabinet dryers designed by the Biochemistry Department, and whose efficiency has been tested to be efficient was used for the studies to access its effect on the nutritional and sensory qualities of two mango cultivars fruits slices.

The broad objective of the project was;

To produce dried mango fruit slices with good nutritional, sensory and storage properties and acceptable to consumers using the newly designed solar and gas cabinet dryers.

The specific objectives were;

1. To investigate the effect of some pre-treatment methods on quality, sensory and nutritional properties of solar cabinet dried mango fruits slices.
2. To compare the effect of solar cabinet dryer and gas cabinet dryers on the nutritional and sensory qualities of dehydrated mango fruits slices.
3. To investigate the effect of some packaging materials and storage time on the nutritional and sensory quality of solar and gas-dried mango fruits.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 MANGO

2.1.1 TAXONOMY, AND ORIGIN

The botanical name for the mango plant is *Mangifera indica*. It belongs to the Anacardiaceae family to which cashew nut and some other fruit crops belong (Samson, 1986).

The genus is a native to South-East Asia and consists of 62 species. About 16 of these have edible fruits but apart from mango, only *M. caesia, M. foetida and M. odorata* are regularly eaten, although they strongly taste of turpentine (Samson, 1986).

The name *Mangifera indica,* assigned by Linne, suggests an Indian origin but this is not at all certain. It is more likely that the origin lies in the Burma-Malesian region. Yet the name is appropriate, as this fruit has been cultivated in India for more than four hundred years (Samson, 1986). From here it spread to other countries in the region. Persians sailors took it to East Africa, probably in the tenth century A.D. and Portuguese travellers in the 16^{th} century brought the mango to West Africa and South America. Since then the mango has been introduced into every tropical country in the world.

2.1.2 DISTRIBUTION AND PRODUCTION

Between 1971 and 1993, the production of mango (*Mangifera indica L.),* worldwide, has increased by nearly 50% (F.A.O. Production Year book, 1971 to 1993). Much of this new production has occurred outside the traditional centres of mango cultures, in South and Central America, Africa and Australia and a significant proportion of the new mango production is for export markets. The high esteem in which this fruit has always been held in Asia, where mango has been cultivated to be the king of fruits (Purseglove, 1969), is now apparently true for much of the world.

Mangoes are now widely available as fresh fruit and in the form of frozen and processed products, not only in the tropics and subtropics, but also year-round in North America, Japan and Europe.

India has the largest mango cultivation area by far, about one million hectares (Samson, 1986). Cultivation is also widespread in Pakistan, Bangladesh and other countries of the South-East Asia.

The southern sahel is well suited to mango culture and commercial cultivation of the produce are found in Israel, Florida (USA), Mexico, Queensland and Egypt. In Africa, the mango has become naturalised due to germinating discarded seeds in the wild in most areas. Many African mangoes because they are produced from seedlings fruits are strongly flavoured and fibrous. Fruits are seasonal and are consumed locally with a small quantity being exported. Where high-quality improved cultivars are grown some exportation, primarily to Europe, does occur. Africa exporters of mangoes include Kenya, Malagasy, Mali, Senegal, Congo, Burkina Faso, Cote D'Ivoire and Southern African countries (Rice *et al*., 1987).

In Ghana the crop does well in savannah and transitional areas, high potential production areas include Central, Greater Accra, Eastern, Volta and Northern regions. The crop is cultivated by both small and large-scale holders with reasonable proportion of the crop growing in the wild. It is estimated that mango crop area in 1997 was about 879 hectares (See Table 1). These include exotic, local and mixed varieties.

About 60 % of the total area (527 hectares) beared matured fruits in 1997 thus giving an annual total production of 5,797 mt. In (Table 1 and 2) are the production estimates for 1997 and the subsequent four years.

Table 1: Projected Production Estimates of Mango in Ghana (1997)

	YEAR				
	1997	1998	1999	2000	2001
Area (Ha.)	879	1,010	1,172	1360	1578
Area (Ha) bearing	527	606	703	816	947
Production (Mt.)	5,797	6,680	7,730	8,970	10,417

Source: MOFA Survey Results on selected non – traditional crops in Ghana 2000

Table 2: Estimated 1997 Mango Crop Area by Region in Ghana

Region	**Estimated Cultivated Area (in Hectares)**
Brong-Ahafo	**39**
Ashanti	**37**
Central	**147**
Eastern	**133**
Greater Accra	**218**
Northern	**78**
Upper East	**69**
Upper West	**62**
Western	**32**
Volta	**64**
Total	**879**

Source: MOFA Survey Results on selected non – traditional crops in Ghana 2000

Table 3: The Major Producers of Mango Worldwide (x 1,000 tonnes)

Country	Year					
	1975	**1980**	**1981**	**1982**	**1983**	**1984**
India	8,500	8,363	8,516	8,500	8,700	8,919
Mexico	389	581	620	663	665	670
Brazil	615	530	560	600	600	520
Pakistan	605	550	550	552	683	683
Philippine	250	374	380	390	550	550
Indonesia		345	444	340	344	360
China	203	276	341	338	353	387
Haiti	278	362	330	355	340	340
Bangladesh	284	207	203	203	182	185
World	12,664	13,091	13,507	13508	13954	14,213

SOURCE: FAO Production Year book 1982

2.1.3 DESCRIBTION

2.1.3.1 FOLIAGE

Mango forms an erect, well-branched evergreen tree with dense crown. The leaves are spirally arranged and come out in reddish flushes that initially hang straight down (Samson, 1986).

Later they take on a more horizontal position and turn green; they stay on the tree for one to three years. There are two to five flushes a year, depending on the climate. The leaf blade is elliptic or oval, 15-40 cm long and 2-10 cm wide.

The midrib is prominent, with 30 pairs of lateral veins. Stomata are present on both sides, but mainly on the lower surface (Samson, 1986). The leaf stalk is swollen at the base and 2-10 cm long.

2.1.3.2 FLOWERS

The inflorescence is a terminal panicle which appears over the entire tree or in only one portion of the tree at any one time. Each panicle branches 3-4 times and consist of 1000 or more mostly male and occasionally hermaphrodite flowers (Litz, 1997).

The proportion of bisexual flowers ranges from 1-1000 per cent, depending on cultivar, climate and weather. The flowers are small, 5-8 mm, usually with five sepals, petals and stamens (only one of which is fertile) and a pistil with an oblique style (Samson, 1986).

2.1.3.3 FRUITS

The mango fruit is a large fleshy drupe, containing edible mesocarp and highly variable with respect to shape and size, chlorophyll, carotenes, anthocyanins and xanthophylls are all present in the fruit. Although chlorophyll disappears during ripening, the anthocyanins and carotenoids increase with maturity (Lakshminaraya, 1980).

The fruit is a large drupe which varies from 5-30 cm in length and often only one form from each inflorescence. The skin is thick and leathery and may be green, yellow or red when ripe, depending on cultivar (Rice *et al.*, 1987). The flesh is orange, sweet, and almost free of fibre in selected cultivars but maybe resinous and fibrous in seedling tree. A fruit may weigh 100 g to 2 kg. The hard, fibrous endocarp encloses a rather large brown seed and may comprise up to 25% of the volume of the fruit.

2.1.4 CULTIVARS

One of the keys to improving mango production in Africa is the identification of cultivars which have good flavour and low fibre content yet which will grow under local conditions. Many cultivars have been imported from India, Australia, the West Indies, Brazil, and the United States and these should be tried in different environment to select the best ones for widespread planting.

Some list of mango cultivars that are of interest in areas other than their places of origin, with descriptions intended to help differentiate them are as follows;

(a) Alphonso (India)

The tree is moderately large, with broadly rounded, dense canopy; the fruit is yellow, ovate -oblique, averaging 6 cm long by 5 cm broad, weighing 225-325 g (mean 266 g), the skin is thin, the flesh is firm to soft and has a very pleasant taste.

(b) Amelie (West Africa)

Also known as “Governeur’’in the Caribbean. The are tall with rounded, dense canopy; the fruit is green to orange-yellow with the advance of the season, round, 10-15 cm long by approximately 10 cm broad by approximately 7-8 cm thick and weighing 300- 600 g (mean 366 g). The skin is thin and separated with difficulty. The flesh is soft, juicy, melting without fibre, a deep orange colour. The fruit closely resemble Julie.

(c) Haden (Florida)

The tree is vigorous, with large, spreading canopy. The fruit is bright yellow with deep crimson or red blush and numerous large yellow dots, oval with rounded base, 10.5-14 cm long by 9-10.5 cm broad by 8.5- 9.5 cm, weighing 510- 680 g (Litz, 1997). The skin is thick, tough, and adherent, flesh firm and juicy with abundant fibre, deep yellow, rich and sweet with pleasant aroma of good to excellent quality.

(d) Irwin (Florida)

The tree is small to medium, moderately, with open canopy. The fruit bright yellow with crimson or dark red blush, numerous large white dots, ovate with rounded base, 11.5-13 cm long by 8-9 cm by 6.5-7.5 cm thick, weighing 340-450 g. The flesh is soft, tender, and juicy without fibre.

(e) Julie (West Indies)

Also called "St. Julienne ''. The tree is compact (quite dwarf in Florida), with a dense canopy; the fruit is green-yellow with light pink to maroon blush and numerous small white dots, rounded with flattened apex, pronouncedly compressed laterally, 7-9.5 cm long by 4-7.5 cm broad by 2.5 cm thick, weighing 200-325 g with a thin, tender skin and soft, melty, juicy orange flesh with scanty fibre, of rich, spicy flavour with a strong, pleasant aroma (Litz, 1997).

(g) Keitt (Florida)

The tree is medium-sized, moderately vigorous, upright with open canopy; the fruit is greenish yellow, with pink or red blush, numerous small white or yellow dots, oval, with rounded base, 13-15 cm long by 9-11 cm broad by 8.5-10 cm thick weighing 510-2000 g (Litz, 1997). The skin is thick, tough and adherent; the flesh is firm and juicy, with little fibre, lemon yellow, sweet and wild with a pleasant aroma. There are late season varieties. After "Tommy Atkins" the most important commercial cultivar in Florida and resistant to anthracnose disease, packaging and shipping stress. They are heavily productive (Campbell, 1992).

(h) Kent (Florida)

The tree is large vigorous, with dense, upright canopy. The fruit is greenish-yellow with red or crimson blush, numerous small yellow dots, and oval, with rounded base, 11-13 cm long by 9.5-11 cm broad by 9-9.5 cm thick, weighing 600-750 g. The skin is thick, though

and adherent, with flesh being firm, tender and melting and juicy with little fibre. Flesh has a deep orange yellow colour, sweet with a rich flavour and pleasant aroma, of excellent quality. It is a late midseason to late season variety and may alternate in their bearing behaviour. Kent is not commonly commercial in Florida because it is prone to storage disease, but is a successful commercial cultivar in drier parts of Morocco, Central America, West Africa (Campbell, 1992).

(i) Sensation (Florida)

The tree is vigorous, with moderately open, symmetrical canopy. The fruit is dark yellow with prominent dark red to purple blush that covers most of its surface, oval with rounded base and rounded apex, 9-11.5 cm long by 7-8 cm broad by 6.5-7 cm thick, weighing 280-340 g (Litz, 1997). The skin is medium thick, juicy, fibreless, deep yellow, mild and sweet with a weak pleasant aroma.

(j) Tommy Atkins (Florida)

The tree is vigorous, with dense, rounded yellow canopy. The fruit is orange to yellow, with crimson or dark red blush and numerous small white dots, oval to oblong, with broadly rounded base, 12-14.5 cm long by 10-13 cm broad by 8.5-10 cm thick weighing 450-700 g (Litz, 1997). The skin is thick, tough and adherent with firm flesh and medium juicy, with some amount of fibre. It is lemon to deep yellow, mild and sweet with strong pleasant aroma.

(k) Turpentine (West Indies)

The tree is vigorous, with large spreading rounded canopy. The fruit is bright yellow with a few large white dots, occasionally with a pink blush oval with a flattened base, 7.5-8.5 cm long by 6.5-7.5 cm broad by 6-6.5 cm thick, weighing 140-200 g. The skin is thick, tough and easily separating with firm flesh and juicy with abundant course fibre, lemon yellow with pleasant aroma.

(l) Zill (Florida)

The tree is vigorous and tall with an open, spreading canopy. The fruit is greenish yellow to yellow with intense red or crimson blush, oval to ovate with base slightly flattened, apex rounded to bluntly flatten with a small beak, 8.5-10 cm long by 7.5-8.5 cm broad by 6-7 cm thick, weighing 230-370 g (Litz, 1997). The skin is thin, tender and adherent. The flesh is pale yellow, soft and juicy without fibre, mild and sweet with a strong pleasant aroma, of good to excellent quality. Zill does not withstand storage and shipping stresses well, and thus is not favoured for commerce (Campbell, 1992).

2.1.6 NUTRITIONAL PROPERTIES OF MANGO

The mango fruit has a high nutritive value and it is the most popular fruit of the orient and has been called King of the fruits, but also “a ball of tow soaked in turpentine” (Samson, 1986). Fruits from seedling trees may have an unpleasant aroma. On the other hand, fruit from the better cultivars has melting yellow flesh, good flavour and a fine aroma. People tasting it for the first time often compare it to the peach. In many places in the tropics it is the chief food fruit of the summer months, and may be considered the tropical equivalent of the apple in the diet. The fruit can be used for some purpose in all stages of development from the tiny imperfectly set fruits, that shed profusely on to develop beyond the initial stage, to the fully mature ones. At the first windfall stages the fruit is gathered for pickles and chutney coming as it does as the first material after the dry season. The tender green fruits are also chopped up for use in lieu of tamarind in various dishes where an acid flavour is desired. The tender leaves are used for salads. No other fruit compares in flavour with the mango when ripe. Each variety has some disguising characteristic and difference in flavour from the others. The ripe fruit blends well with dairy products sliced and served with cream and sugar, or with ice cream, the combination is beyond description. Mango fruit contain amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins, and vitamins (Litz, 1997). During the ripening process, the fruit are initially acidic, astringent and rich in ascorbic acid (vitamin C). Ripe mangoes contain moderate amount of vitamin C but are fairly rich in pro-vitamin A and vitamin B1 and B2. The pulp of the mango fruit contains as much vitamins as butter. Fruit acidity is primarily due to the presence of malic and citric acids. In addition, oxalic, malonic, succinic, pyruvic, adipic, galacturonic, glucuronic, tartaric, glycolic and mucic acids are also present. Following fruit set, starch accumulates in the mesocarp. Free sugars including fructose and sucrose generally increase during ripening, however, the sucrose

content increases three to fourfold due to hydrolysis of starch. Sucrose is the principal sugar of ripe mango. The composition of the edible portion of the fruit is shown in (Table4).

Table 4: Mango Composition per 100g of Raw Edible Portion

Energy	65.0 kcal = 273 kj
Protein	0.510 g
Carbohydrate	15.2 g
Fibre	1.80 g
Vitamin A	389 µg RE
Vitamin B1	0.058 mg
Vitamin B2	0.057 mg
Niacin	0.717 mg NE
Vitamin B5	0.134 mg
Folate	14.0 µg
Vitamin B12	-
Vitamin C	27.7 mg
Vitamin E	1.12 mg
Calcium	10.0 mg
Phosphorus	11.0 mg
Magnesium	9.00 mg
Iron	0.130 mg
Potassium	156 mg
Zinc	0.040 mg
Total Fat	0.270 g
Saturated Fat	0.066 g
Cholesterol	-
Sodium	2.00 mg

Source: Pamplona and Roger (2007).

2.2 USES OF MANGO

Mango is the most popular fruit of the orient and has been called ‘king of fruits’, but also a ball of tow soaked in turpentine or ‘fit to be eaten in the bathtub only’. Fruit from seedling trees may be stringy and watery or may have an unpleasant aroma. On the other hand, fruits from the better cultivars have melting yellow flesh, good flavour and a fine aroma. People tasting it for the first time often compare it to the peach.

Ripe mangoes are eaten for dessert, are canned or used for making juice, jams and other preserves. Pickles and chutney are prepared from unripe fruits, or a powder is ground from them, after slicing and drying. Seeds and leaves can be eaten or feed to cattle in times of food shortage, but prolong feeding may result in death (Purseglove, 1968).

2.2.1 Natural Benefits and Curative Properties

Revered not only for their exotic sweetness and juicy quality, mangoes are known for their many health benefits. They contain an enzyme similar to papain in papayas, a soothing digestive aid. Eating mangoes helps maintain healthy skin and has been proven that vitamin A deficiency produces skin dryness and scaling. Mango contributes to proper skin hydration and tone. Mangoes are diuretic (increase urine production). They are quite rich in potassium and low in sodium and this makes them highly recommended in cases of high blood pressure since they aid in its control (Pamplona and Roger, 2007). Diabetics can benefit from eating mangoes because the fruit has positive effect on the arteries and help prevent the circulatory complications associated with diabetes. In India mangoes are used as blood builders. Because of their iron content they are suggested for treatment of anaemia and are beneficial to woman during pregnancy and menstruation. People who suffer from muscle cramps, stress, and heart problems can benefit from the high potassium and magnesium content that also helps those with acidosis.

2.2.2 MANGO PROCESSING TECHNOLOGIES

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. Mangoes are processed into many other products for home use and by cottage industry. The processed mango presents many problems as far as industrialization and market expansion is concerned. The trees are alternate bearing and the fruit has a short storage life; these factors make it difficult to process the crop in a continuous and regular way. The large number of varieties with their various attributes and deficiencies affects the quality and uniformity of processed products. The lack of a simple, reliable method for determining the stage of maturity of varieties for processing in developing countries also affects the quality of the finished products. Many of the processed products require peeled or peeled and sliced fruit. The lack of mechanised equipment for the peeling of ripe mangoes is a serious problem for increasing the production of these products. A significant problem in developing

mechanized equipment is the large number of varieties available and their different sizes and shape. The cost of processed mango products is also too expensive for the general population in the areas where most are grown. There is, however, a considerable export potential to developed countries but in these countries the processed mango products must compete with established processed fruits of high quality and relatively low cost.

2.2.3 GREEN MANGO PROCESSING

Green firm mango fruits with developed stone but unripe are processed into traditional products like brine stock, pickles, chutneys and dried powder. Instant mango pickles, drum-dried green mango powder and raw mango beverage base are the newest developments.

(a) PICKLES

Pickles are classified as salt pickles or oil pickles. The oil used is either mustard or ginger oil. Salt cured slices are drained, mixed with spices and oil, packed into glass jars and sealed properly. Extra oil is added to form a 1-2 cm layer over the pickle to prevent exposure to air (Bhatnagar and Subramanyam, 1973).

(b) CHUTNEY

There are two types of commercially important chutney; these are sweet chutney and hot chutney. Sweet chutney is prepared from either fresh or brined slices (5 cm length and 0.6 cm thickness). The fruit pieces are mixed with sucrose and salt and cooked along with a spice mixture of coarsely ground clove, cardamom, dried ginger and red chilli powder to a jam consistency. Vinegar or food grade glacial acetic acid is added and mixed well. This is then packed hot into presteriled bottles and sealed air-tight. The hot chutney preparation is similar to that of sweet chutney except that more spices and less sucrose are used in the recipe.

(c) MANGO SLICE IN BRINE

Unripe mango slices are preserved with salt for later conversion into pickles, chutney or as salt stock for export. The method consists of adding 15-20% salt to prepared slices (5 cm length and 0.6 cm thickness), draining the liquid formed therein and replacing it with fresh salt.

(d) DRIED GREEN MANGO POWDER

Raw mango slices dried in the sun or in a mechanical drier and powdered is referred to as amchur in the trade and is used in culinary preparation for traditional Indian cooking.

(e) RAW MANGO BEVERAGE

This is a traditional product prepared and consumed in most households in India. A commercial process has been developed to prepare raw mango beverage base and preserved by bottling. Gel formation is observed in the bottled base and this problem can be overcome by enzymatic treatment of the pulp (Anonymous, 1985-86). Under ambient storage conditions, the product can keep for more than a year.

(f) RIPE MANGO

Ripe mangoes (mature and post-climacteric ripe fruit with full flavour development) are processed into (i) frozen mango products, e.g. slices in syrup, pulp and beverage base, (ii) canned products, e.g. slice in syrup, pulp, juice and nectar, (iii) read-to-serve beverages and (iv) dehydrated products e.g. mango fruit bar, mango cereal flakes, mango powder, strained baby foods, mango toffees, etc. Canned mango slices in juice, mango concentrate, mango aroma concentrate, low viscosity and low pulp containing mango concentrate beverage base, aseptic bulk packing of pulp and concentrate, structured mango products are relatively new product development.

(g) FROZEN MANGO SLICES IN SYRUP

Hand-peeled, sliced Alphonso and pairi mango varieties have been frozen in cans. The fruit slices are covered with sucrose syrup (40-50° Brix) containing citric and ascorbic acid, and frozen at - 18°C maintains the slices natural colour and flavour (Kirpal Singh, 1970).

(h) FROZEN MANGO PULP (PUREE)

Mango pulp from Alphonso and Pairi mango varieties with added sucrose (20%) can remain in good condition after 12 months storage at -18°C. Addition of citric acid (200 $mg1^{-1}$) and ascorbic acid (50 $mg1^{-1}$) help to retain colour and flavour.

(i) CANNED MANGO SLICE IN SYRUP

Mangoes are generally canned at the just ripe stage as slices, cheeks or dices. Prepared slices are filled into plain cans (102 x119 mm size), and covered with hot syrup (30-50ºBrix), depending upon the variety, exhausted, sealed and processed for 15 min at 100ºC and cooled.

(j) MANGO BEVERAGES

Popular mango beverages include mango juice, nectar, ready-to-serve beverage, squash and syrup. They are prepared by mixing mango pulp, sugar, citric acid and water.

(k) MANGO TOFFEE

Mango toffee can be prepared by mixing mango pulp (53 kg) with sucrose (30 kg), glucose (4 kg), and skim milk powder (5 kg) and hydrogenated fat (5 kg) and cooking in a steam jacketed kettle until the final weight of the material is 1.2 times the original pulp mass. The cooked mass is transferred to a level and smoothly greased tray and the product is spread into a thin sheet (1 cm thick). It is then allowed to cool and set. The solid sheet is cut into suitable size and wrapped in cellophane paper and packed in air tight tins.

(l) DEHYDRATED MANGO SLICES

Mango slices dried by sun-drying, cross-flow air-drying and through-flow air drying have been compared. Through-flow air drying is the most efficient process.

(m) OSMOTIC DEHYDRATION

Mango slices have also been successfully dehydrated by dehydration using sugar syrup (70ºBrix) as osmotic agent. After osmosis the pieces are dipped in sulphite solutions, drained and the pieces air-or vacuum-dried.

(n) MANGO FRUIT BAR

Mango fruit bar is a confectionary prepared by mixing mango pulp with calculated amounts of sucrose heated to 80ºC, cooled and mixed with potassium metabisulphite. The pulp thus prepared is spread on a tray and dried in a cross flow air drier at 70ºC until the moisture is below 15%. The dried sheet is cut into suitable sizes and wrapped in cellophane or glossing paper.

2.3 DRYING

Drying is an ancient method of preservation of food and this involves the removal of majority of the water normally present in the food by evaporation, or in other cases freeze drying by sublimation under vacuum to yield a dried product. This occurs under controlled conditions of temperature and pressure (Mazza and LeMaguer, 1980). This definition excludes the processes which involves the mechanical extraction of water out of food such as membrane concentration, gravity concentration, and mechanical separation and baking, as these normally removes less water as compared to drying (Treybal, 1980).

During drying, water is removed in the form of vapour as heat is supplied to the food material, therefore, heat and mass transfer occurs simultaneously. It requires a safe place to spread the food where dry air in large quantities can pass over and beside thin pieces (DeLong, 1979). Drying is achieved by the direct use of energy produced by the sun or from other means of heating such as electricity and fuel. Of these, sun is the most abundant and economical (Treybal, 1980).

Dehydration, or drying, is a simple, low-cost way to preserve food that might otherwise spoil. Drying removes water and thus prevents fermentation or the growth of moulds. It also slows the chemical changes that take place naturally in foods, as when fruit ripens. Surplus grain, vegetables, and fruit preserved by drying can be stored for future use.

People have been drying food for thousands of years by placing the food on mats in the sun. This simple method, however, allows the food to be contaminated by dust, airborne moulds and fungi, insects, rodents, and other animals. Furthermore, open air-drying is often not possible in humid climates (DeLong, 1979). There are several types of drying methods including;

-Sun (solar) drying

-Freeze drying

-Drum drying

-Tunnel drying.

2.3.1 SOLAR DRYING

Salunkhe *et al.,* (1991) defined solar drying as the process of using solar radiation as the heat source for drying a product, where a system is either used to increase the radiation flux absorbed by the product or to transfer the absorbed radiation onto the product. In contrast to water heating and the generation of electricity, crop drying utilizes the sun's energy directly (Archuleta *et al.,* 1983, Gregoire *et al.,* 1981). Using solar energy to dry

crops is nothing new in the tropics. Many edible and even cash crops such as cocoa and coffee beans have for decades been dried on racks placed in the sun. Sun is often used to provide the hot dry air for drying.

Solar food dryers represent a major improvement upon this ancient method of dehydrating foods. Although solar dryers involve initial expenses, they produce better testing and more nutritious foods, enhancing both their food value and their marketability. They are also faster, safer and more efficient than traditional sun drying techniques. An enclosed cabinet-style solar dryer can produce high quality dried foodstuffs in humid climates as well as arid climates. It can also reduce the problem of contamination. Drying is completed more quickly, so there is less chance of spoilage. Fruits maintain a high vitamin C content. Because many solar dryers have no additional fuel cost, this method of preserving food also conserves non-renewable sources of energy. In resent years, attempts have been made to develop solar dryers that can be used in agricultural activities in developing countries. Many of the driers used for dehydration of foods are relatively low-cost compared to systems used in developed countries.

Solar drying is an advanced form of sun drying. In this case the direct radiation from the sun is prevented from having direct contact with the food, in effect, the radiation is filtered and collected into an appropriate chamber where drying and heat generation will be high.

2.3.2 PRINCIPLE AND MECHANISM OF SOLAR DRYING

2.3.2.1 PRINCIPLE OF DRYING

Imagine a close heated space in which a damp agricultural crop has been stored. Two things happen in the crop:

-The crop is warmed by the heat from the stove or fire

-Air around the heat source is heated up-whereby it can take up a great deal of moisture and the air is rising and is continually replaced.

As the crop is warmed up, including the air between the plant fibres, the water it contains quickly evaporates. Pretty soon the air within and surrounding the crop is saturated with water vapour. Fortunately the air moving alongside, warm and unsaturated can take up this moisture and transport it away. A small fan will of course help this process, but it is not strictly necessary. At a certain moment the air in the room or dryer has taken up so much moisture from the crop that the windows suddenly mist up (though this will depend

on the outside temperature); the air against the cold windows has been cooled to below the ′dew point′.

In this way the water in the crop is transferred to the window panes, where it can be wiped off, or allowed to fall into a gutter which leads outside the room. If, in this account, the heat source is replaced by sun, a solar drier has effectively been described. The cold window (which works as a condenser) is sometimes encountered in indirect drying, where the warming of the air and the drying of the crop are separate.

Solar drying is a technique particularly suited to the warmer parts of the world, since;

-There is abundant sunlight.

-The air temperature is high and relatively constant over the whole year. Kordylas (1991) outlined the following ideal conditions as most suitable for solar drying:

-Food item must be out of direct sunlight

-Food must not be heated directly but instead by warm air constantly moving across the food surface

-Moisture or water vapour must be constantly removed from the drying food

-A temperature range of 35-38ºC must be constantly maintained.

Of the total amount of energy released by the sun, only a fraction reaches the earth's surface after passing through the atmosphere. Of this, half is visible light and half is heat (Kordylas, 1991). The wavelength of the solar radiation at the earth surface ranges from 0.3 to 3.0 μm and called short wave. Though these are able to pass through clear substances, they are absorbed by black objects, which in turn emit heat radiation with wavelengths of more than 3.0 μm (long waves). Long wave radiation cannot pass through some clear materials .Thus if a black material lying on an insulated base and covered with such a clear material placed under the sun, it can act as a collector for solar radiation in the form of heat (Ihekoronye and Noddy, 1985). The heat collected is use for drying. In such a system, if a small amount of air is held in a confined chamber, it will get warmer no matter how much heat it received from the sun. This air will get hotter if less air is allowed to move through the chamber. In the chamber, warmer air will rise and be replaced by cooled air (Gregoire *et al.,* 1981). Thus convention current would be generated and this can carry away moisture from drying products to be discharged elsewhere (Ihekoronye and Ngoddy, 1985). The relative humidity of the chamber also influence the drying time. A high relative humidity increases the drying time.

2.3.2.2 MECHANISM OF DRYING

Solar dryers use the energy of the sun to heat the air that flows over the food in the dryer. As air is heated, its relative humidity decreases and it is able to hold more moisture. Warm, dry air flowing through the dryer carries away the moisture that evaporates from the surface of the food (Archuleta *et al.,* 1983).

As drying proceeds, the actual amount of moisture evaporated per unit of time decreases. In the first phase of drying, the moisture in the exterior surface of the food is evaporated. Then, once the outer layer is dried, moisture from the innermost portion of the material must travel to the surface in the second phase of drying.

During the second phase of the drying process, overheating may occur because of the lessened cooling effect resulting from the slower rate of moisture evaporation. If the temperature is too high, the food will "case harden" or form a hard shell that traps moisture inside. This can cause deterioration of the food. To prevent overheating during this portion of the drying cycle increased airflows or less heat collection may be desirable.

2.3.3 SOLAR DRYER TYPES

Solar dryer fall into two broad categories: active and passive. Passive dryers can be further divided into direct and indirect models. A direct (passive) dryer is one in which the food is directly exposed to the sun's rays. In an indirect dryer, the sun's rays do not strike the food to be dried (Exell, 1980).

A small solar dryer can dry up to 300 pounds of food per month; a large dryer can dry up to 6,000 pounds a month; and a very large system can dry as much as 10,000 or more pounds a month (Gregoire *et al.,* 1981). Figures are base on harvests in temperate climates.

Passive dryers use only the natural movement of heated air. They can be constructed easily with inexpensive, locally available materials. Direct passive dryers are best used for drying small batches of foodstuffs. Indirect dryers vary in size from home dryers to large-scale commercial units.

(a) ACTIVE DRYERS

Active dryers require an external means, like fans or pumps, for moving the solar energy in the form of heated air from the collected area to the drying beds. These dryers can be built in almost any size, from very small to very large, but the larger systems are the most economical (Gregoire *et al.,* 1981).

Either air or liquid collectors can be used to collect the sun's energy. The collectors should face south if you are in the northern hemisphere (Exell, 1980, Gregoire *et al.*, 1981). At or near equator, they should also be adjusted east or west in the morning and afternoon, respectively.

The collectors should also be positioned at an appropriate angle to optimize solar energy collection for the planned months of operation of dryer. The collectors can be adjacent to or somewhat remote from the solar dryer. However, since it is difficult to move air over long distance, it is best to position the collectors as near the dryer as possible. The solar energy collected can be delivered as heat immediately to the dryer air stream, or it can be stored for later use. Storage systems are bulky and costly but are helpful in areas where the percentage of sunshine is low and a guaranteed energy source is required; or in carrying out round-the-clock drying (Archulata *et al.*, 1983).

In an active dryer, the solar-heated air flows through the solar drying chamber in such a manner as to contact as much surface area of the food as possible. The larger the ratio of food surface area to volume, the quicker will be the evaporation of moisture from the food. The sliced foods are placed on drying racks or on trays made of a screen or other material that allows drying air to flow to all sides of the food. For grain products, pipes with many holes are placed at the bottom of the drying bin with grain piled on top. The heated air flows through the pipes and is released upward to flow through the grain, carrying away moisture as it flows (Exell, 1980).

(b) Passive Dryers

Passive solar food dryers use natural means of radiation and convection to heat and move the air. The category of passive dryers can be subdivided into direct and indirect types (Archuleta *et al.*, 1983, Ong , 1978).

(i) Direct Dryers: In a direct dryer, food is exposed directly to the sun's rays. This type of dryer typically consists of a drying chamber that is covered by transparent cover made of glass or plastic. The drying chamber is a shallow, insulated box with holes in it to allow air to enter and leave the box. The food is placed on a perforated tray that allows the air to flow through it and the food. Solar radiation passes through the transparent cover and is converted to low-grade heat when it strikes an opaque wall. This low-grade heat is then trapped inside the box in what is known as the "greenhouse effect." Simple stated, the short wavelength solar radiation can penetrate the transparent cover. Once converted to

low-grade heat, the energy radiates on a long wavelength that cannot pass back through the cover (Archuleta *et al.*, 1983).

The drying chamber can be constructed of almost any material; wood, concrete, sheet metal, etc. The dryer should be 2 meter long by 1 meter wide and 23 to 30 cm deep. The bottom and sides of the dryer should be insulated, with 5 cm of an insulator. Blackening the inside of the box will improve the dryer efficiency, but be sure to use a non toxic material and avoid lead-based paints. Wood blackened by fire may be a safe and inexpensive material to use (Archuleta *et al..*, 1983).

The tray that holds the food must permit air to enter from below and pass through to the food. A wire or plastic mesh or screen will do nicely. Use the coarsest possible mesh that will support the food without letting food to fall through the holes. The larger the holes in the mesh, the easier the air will circulate through to the food. Air holes below the tray or mess will bring in outside air, which will carry away the moisture evaporated from the food (Gregoire *et al.,* 1981). As the air heats up in the dryer, its volume will increase, so either more or large holes will be required at the top of the box to maintain maximum air flow.

(ii) Indirect Dryers: An indirect dryer is one in which the sun's ray do not strike the food to be dried. In this system, drying is achieved indirectly by using an air collector that channels hot air into a separate drying chamber. Within the chamber, the food is placed on mesh trays that are stacked vertically so that the air flows through each one (Gregoire *et al.,* 1981). The solar collector can be of any size and should be titled toward the sun to optimize collection. By increasing the collector size, more heat energy can be added to the air to improve overall efficiency (Gregoire *et al.,* 1981). Larger collector areas are helpful in places with little solar energy, cool or cold climates, and humid regions. Tilting the collector is more effective than placing them horizontally, for two reasons. First, more solar energy can be collected when the collector surface is more nearly perpendicular to the sun's rays. Second, by tilting the collectors, the warmer, less dense air rises naturally into the drying chamber. The drying chamber should be placed on support legs, but it should not be raised so high above the ground that it becomes difficult to work with.

The base of the collector should be vented to allow the entrance of air to be heated for drying. The vent should be evenly spaced across the full width of the base of the collector to prevent localized areas within the collector from overheating. The vents should also be

adjustable so that the air-flow can be matched with the operating conditions and/or needs. Solar radiation, ambient air temperature, humidity level, drying chamber temperature and moisture level of the food being dried must all be considered when regulating the flow of air. The top of the collector should be completely open to the bottom of the drying chamber. Once inside the drying chamber, the warmed air will flow up through the stacked food trays. The drying trays must fit snugly into the chamber so that the drying air is forced through the mesh and food. Trays that do not fit properly will create gaps around the edges, causing large volumes of warm air to bypass the food, and preventing the dryer from removing moisture evaporated from the food.

As the warmer air flows through several layers of food on trays, it becomes moister. The moist air is vented out through a chimney (Archuleta *et al.,* 1983). The chimney increases the amount of air flowing through the dryer by speeding up the flow of the exhaust air. As the warm, moist air flows through the solar chimney, the additional solar energy entering the chimney warms the escaping air further. This added heat makes the air less dense and causes it to flow up through, and out of, the solar chimney at a faster rate, thereby bringing in more fresh air into the collector (Gregoire *et al.,* 1981).

2.3.4 PRINCIPLE AND MECHANISM OF GAS CABINET DRYERS

Conventional fuel dryers come in different forms and designs. Sources of energy used for such dryers could come from fuel wood, L.P.G. gas, and butane gas, coal and fossil fuels.

The liquefied petroleum gas L.P.G. dryers are a form of conventional fuel dryers that uses L.P.G. gas to dry agricultural produce.

The gas cabinet dryers operate on the principle of the solar dryers. The heat generated in the chamber heats up the surrounding air which then rises in the chamber and carries moisture along with it from the drying product and discharges it through an outlet vent on the upper portion of the dryer.

2.3.5 COMPARING THE DRYING ALTERNATIVES

2.3.5.1 FOSSIL-FUEL DRYERS VERSUS SOLAR DRYERS

Conventionally fuelled dryers are the primary alternative to solar dryers. In conventional dryers, a fuel is burned to heat the food-drying air. In some cases, the gaseous products of combustion are mixed with the air to achieve the desired temperature. Although these drying systems are used around the world with no apparent problems, there is the

possibility of a mechanical malfunction, which might allow too much gas into the drying stream. If this occurs, the food in the dryer can become contaminated.

The great advantage that conventional dryers have over solar dryers is that drying can be carried out around-the clock for days on end, in any kind of weather. Unlike solar dryers, conventional dryers are not subject to daily and seasonal variations and other climatologically factors (Wilson and Schemske, 1980).

On the other hand, the fuels burned in conventional dryers may present other problems as;

1. Use of wood may contribute to problems of deforestation
2. Coal may cause pollution
3. Fossil fuels are becoming increasingly expensive and are not always available.

2.3.5.2 ADVANTAGES OF SOLAR DRYERS

The principal advantage of using solar energy is a free, available and limitless energy source that is also non-polluting. Drying most foods in sunny areas should not be a problem.

Most vegetables, for example, can be dried in 2-1/2 to 4 hours, at temperatures ranging from 43 to 63 °C. Fruits take longer, from 4 to 6 hours, at temperatures ranging from 43 to 66°C. At this rate, it is possible to dry two batches of food on a sunny day.

A solar food dryer improves upon the traditional open-air systems in five important ways (van Brakel, 1978):

1. It is faster. Foods can be dried in a shortened amount of time. Solar food dryers enhance drying times in two ways. First, the transparent glazing over the collection area traps heat inside the dryer, raising the temperature of the air. Second, the capability of enlarging the solar collection area allows for the concentration of the sun's energy.
2. It is more efficient. Since foods can be dried more quickly, less will be lost to spoilage immediately after harvest. This is especially true of produce that requires immediate drying such as fruits with high moisture content. In this way, a larger percentage of food will be available for human consumption. Also, less of the harvest will be lost to marauding animals, vermin, and insects since the food will be in an enclosed compartment.
3. It is safer. Since foodstuffs are dried in a controlled environment, they are, less likely to be contaminated by pests, and can be stored with less likelihood of the growth of toxic fungi.

4. It is healthier .Drying foods at optimum temperature and in a shorter amount of time enables them to retain more of their nutritional value specially vitamin C. An extra bonus is that foods will look and taste better, which enhances their marketability.
5. It is cheaper. Using solar energy instead of conventional fuel demand can result in significant cost savings. Solar drying lowers the cost of drying, improving the quality of product, and reduces losses due to spoilage.

2.3.4.3 DISADVANTAGES OF SOLAR DRYERS

Solar dryers do have shortcomings. They are of little use during cloudy weather. During fair weather they can work too well, becoming so hot inside at midday as to damage the drying crop. Only with close supervision can this be prevented. As temperatures rise (determined with a thermometer or by experience), the lower vents must be opened to allow great airflow through the dryer and to keep the temperatures down. Rice, for example, will crack at temperatures above 50 ºC, seed grains can be dried at temperatures below 40 to 45 ºC.

2.4 PRE-TREATMENT OF FRUITS BEFORE DRYING

Fruits and vegetables undergo several undesirable reactions during drying to yield products with low nutritional and sensory qualities. To prevent these from occurring, most fruits and vegetables are pre-treated prior to heating to achieve the desired product.

2.4.1 Inhibition of Browning Reaction during Drying

Enzymatic browning requires four different components; these are oxygen, an enzyme, copper and a substrate. The most common enzyme in minimally processed vegetables and fruits is polyphenol oxidase (PPO) (Oszmianski and Lee, 1990; Sapers and Douglas, 1987. Polyphenol oxidase is a generic term for the group of enzymes that catalyse the oxidation of phenolic compounds to produce a brown colour on the cut surfaces of vegetables and fruits (Whitaker and Lee, 1995; Sapers and Miller, 1992, 1993, 1995). Peeling and cutting are key steps in the preparation of minimally processed vegetables and fruits. During these operations cell membranes are broken, and appropriate substrates come into contact with oxidizing enzymes. In the presence of oxygen, rapid browning occurs due to the enzymatic oxidation of phenols to orthoquinones, which rapidly

polymerize to form brown or black pigments, such as melanin's (O'Beirne, 1995; Sapers and Douglas, 1987).

Enzymatic browning or raw discoloration can proceed very quickly, even in 0.5 h. In the potato and fruits processing industry, minimally processed potatoes (whole, slices, strips) usually experience delays before further processing takes place. These delays may extend for an hour to several days (i.e. over a weekend) leading to the appearance of the above-mentioned defects. The most important factors that determine the rate of enzymatic browning of vegetable and fruits are the concentration of active PPO and phenolic compounds present, the pH, the temperature and the oxygen availability of the tissue.

The optimum pH of PPO activity varies with enzyme source and with substrate over a relatively wide range. In most cases, the optimum pH range of PPO is between pH 4 and 7. The adjustment of pH with acids to 4 or below can be used to control browning as long as the acidity can be tolerated taste wise. The temperature stability of PPO varies with species and cultivars. The enzyme is relatively heat labile and activity is completely destroyed at 80°C (Vamos-Vigyazo, 1981). Heat inactivation of PPO is feasible by applying temperatures of more than 50°C but may produce undesirable colours and/or flavours as well as undesirable changes in texture.

Much can be done to reduce browning occurring during storage or processing by selecting cultivars of low browning tendency (Amiot *et al.,* 1992) and by appropriate agricultural techniques (Mondy and Munshi, 1993). The rate of brown discolouration in minimally processed vegetables varies according to pre- and post harvest factors. Among cultural factors, the choice of cultivar has been reported to have effect on the browning of prepared vegetables, since different fruits and vegetable may have different chemical compositions. However, there are some indications that fertilizer practices may mask cultivar differences. Among the post harvest techniques that may affect browning are, transport and storage of intact fruits and vegetables have shown to play a role in the rate of browning of prepared fruits and vegetables.

2.4.2 Methods for Preventing Browning

In theory, PPO-catalysed browning of vegetables and fruit can be prevented by heat inactivation of the enzyme, inclusion or removal of one or both of the substrates (oxygen and phenols), lowering the pH to 2 or more units below the optimum, or adding

compounds that inhibits PPO or prevent melanin formation (Whitaker & Lee, 1995). Many inhibitors of PPO are known, but only a few have been considered as potential alternatives to sulphites (Vamos-Vigyaza, 1981).

Lozano-de-Gonzalez *et al.* (1993) and Meza *et al.,* (1995) have obtained promising results with lemon juice. It appears to be a good potential alternative to sulphites for the prevention of browning in fresh apple rings. Treatment of white grapes and cut fruits with ascorbic acid has shown to inhibit PPO activity and browning. The browning susceptibility of potatoes can also be reduced to some extent by heat treatment (85-100°C for 3-5 minutes) before peeling. This is mainly due to the fact that the amount of reducing sugars decreases during the heat treatment (Mattilla *et al.,* 1995).

(a) Chemical methods

Probably the most frequently studied alternative to sulphite is ascorbic acid. This compound is a highly effective inhibitor of enzymatic browning, primarily because of its ability to reduce quinones back to phenolic compounds before they can undergo further reaction to form pigments. Unfortunately, once the ascorbic acid has been completely oxidized to dehydroascorbic acid (DHAA), quinones can accumulate and undergo browning. According to Sappers and Miller (1995) digestion with hot ascorbic/citric solutions improves the shelf-life of pre-peeled potatoes. A shelf-life of about two weeks was obtained. Erythorbic acid, an isomer of ascorbic acid, has been used as an inhibitor of enzymatic browning in combination with ascorbic acid or citric acid for potato slices (Dennis, 1993) and for whole abrasion-peeled potatoes (Santerre *et al.,* 1991). Lambrecht (1995) found that erythrobic acid and ascorbic acid were equally effective in preventing browning in pineapple slices.

Citric acid acts as chelating agent and acidulant, both functionalities inhibiting PPO. Reliable and promising results have been obtained using citric acid as dipping treatment for minimally processed fruits and vegetables (Mattila *et al.,* 1995). Weller *et al.,* (1997) found that treating carambola slices with 1.0 or 2.5% citric acid and 0.25% ascorbic acid in water prior to packaging was very effective in limiting browning. 4-Hexylresorcinol (4HR) is one of the recently discovered, patented and proposed browning inhibitors of aromatic compounds (McEvily *et al.,* 1991; Dubley and Hotchkiss, 1989). 4-Hexylresorcinol is a good inhibitor of enzymatic browning for shrimps, apples, potatoes

and iceberg lettuce (Monsalve Gonzalez *et al.,* 1993; Luo and Barbosa-Canovas, 1995; Whitaker and Lee, 1995; Castaner *et al.,* 1996). 4-Hexylresorcinol interacts with PPO and renders it incapable of catalysing the enzymatic reaction. 4-Hexylresorcinol has several advantages over using sulphites in foods, including its specific mode of inhibitory action, ineffectiveness at lower levels, its inability to bleach preformed pigments and its chemicals stability (McEvily *et al.,* 1992). 4-Hexylresorcinol is the active ingredient in one commercial browning inhibitor, EverFresh (Lambrecht, 1995; Gardner *et al.,* 1991).

(b) Enzymatic methods

Protease enzymes were found to be effective browning inhibitors for apples and potatoes (Luo, 1992). It is believed that an effective protease acts to hydrolyse and, therefore inactivates the enzymes responsible for enzymatic browning. Of the proteolytic enzyme tested so far, mainly 3 plant proteases (ficin from figs, papain from papaya and bromelain from pineapple) proved to be effective.

(c) Physical Methods

The most common physical method of inhibiting browning reaction in fruits and vegetables is through blanching. This can either be steam or water blanching. Steam blanching is suggested for some fruits to reduce discolouration and nutrient loss during drying. It also softens fruits so they dry faster (Nisperos-Carriedo *et al.,* 1988).

(d) Sugaring by soaking

Mainly used for fruit, the technique of sugaring consists in soaking the product in concentrated sugar solution. The difference in concentration between the product and the solution leads to water migration from the least concentrated environment, i.e. the foodstuff, to the most, concentrated sugary water. The product is thus dehydrated and sweetened (Jean-Francois Rosis 1997).

2.5 PACKAGING AND STORING DRIED FRUITS

Dried fruits are susceptible to contamination and moisture reabsorbtion and must be properly packaged and stored immediately. First, cool the dried fruits completely. Packaging warm fruit causes sweating, which could provide enough moisture for mould to grow (Chasery and Gormley, 1994).

Dried fruit should be stored in cool, dry, dark areas (Kabir, 1994). Recommended storage times for dried fruits range from four months to one year. Because food quality is affected by heat, the storage temperature helps to determine the length of storage. The higher the temperature, the shorter the storage time and vice versa. Most dried fruits can be stored for one year at 10°C, six months at 15°C. Fruits that are packaged seemingly bone-dry can spoil if moisture is reabsorbed during storage. Glass containers are excellent for storage because any moisture that collects on the inside can be seen easily. Fruits affected by moisture, but not spoiled, should be used immediately or redried or repackaged. Mouldy foods should be discarded (Heimdal *et al.*, 1995).

2.6 FACTORS AFFECTING THE STORAGE STABILITIES OF DRIED FRUITS

1. TEMPERATURE- The effect of temperature changes on chemical and biochemical reactions in dried product during storage makes temperature an important factor with respect to quality maintenance. Low temperatures are necessary to maximise storage life. Studies have shown that, deteriorative effects of temperature on rate of chemical changes could be unexpectedly high. For example, rate of non-enzymatic browning reaction may increase two folds for a 4°C rise in temperature (Ahvenainen, 1996).

2. MOISTURE- The influence of moisture content and water activity are of profound importance in determining the shelf-life of most foods. This is because they affect physical (hardening, drying out), and physico-chemical properties, chemical changes, microbial spoilage and enzymatic changes, particularly with unprocessed foods (Ihekoronye and Ngoddy, 1985). For dried foods, it is better to keep the moisture content as low as possible.

3. PACKAGE - Nutrient losses during storage is largely dependent on packaging medium (Salunkhe *et al.*, 1991). The package functions to prevent entry and exit of matter to and from the dried products. If the package is defective, volatile compounds can be lost. The composition of air inside a package has been reported to affect the rate and extent of nutrient loss from foods. High density polyethylene films (HDPE) have lower permeability for water vapour and oxygen diffusion than low-density polyethylene films (LDPE.

4. LIGHT- Light may have an effect on the rate of darkening in some products, and it has been known to cause a reduction in carotene (Bolin *et al.*, 1977).

5. TRACE ELEMENTS - Some salts and metals are detrimental to the nutritional value, flavour, and storage quality of dried fruits and vegetables. These may be picked up during washing or pre-treatment stages. Calcium has a firming effect on texture while sulphur may prevent browning in dried foods. Iron and copper combine with tannins to cause blackening and may accelerate ascorbic acid degradation (Baldwin *et al.*, 1995; Bolin *et al.*, 1977). Magnesium, sodium and calcium sulphates impart bitter flavour. Zinc, cadmium and chromium have toxic effect (Salunkhe *et al.*, 1991). Some of these elements can also be picked up from the packaged material.

2.7 FOOD ADDITIVES

A food additive is any substance not normally consumed as a food in itself and normally used as an ingredient of food, but which is intentionally added to a food to achieve one or more of the technological functions. It is added before, during or after processing of the food. Its by-products may remain in the food. Food additives are distinguishable from processing aids; examples are vitamins and minerals added to food for nutritional purposes (FDA, 1996).

Food standards regulate the use of food additives in the production and processing of food. A food additive may only be added to food where expressly permitted by the standards. Additives can only be added to food in order to achieve an identified technological function according to Good Manufacturing Practices (FDA, 1996).

The maximum permitted level means the maximum the amount of additive which may be present in the food as set out in relation to that food and should not be more than that figure.

Some common food additives used in our every day processing can be categorised as, preservatives (sulphites, benzoic acid), colourants, bleaching agents, thickeners (alginate, pectin), sweetners (monellin, thaumatin), flavourant (vanilla, strawberry), acidulants (citric acid, vinegar), etc. Some of the food additives have multipurpose properties. Citric acid can be used as acidulant and preservative at the same time. Sulphites can be used as preservative, bleaching agent and acidulant. Some of the oldest food additives that have

found use till recent times include sodium chloride and sulphites (Cherry and Singh, 1990; Lund, 1989).

2.7.1 SULPHITES

Sulphur dioxide has been used as a food preservative for a number of years. Indeed it may be the oldest chemical preservative, apart from salt, with the use of burning sulphur to sterilise wine jars being recorded by the Romans. The sulphurous acid that it forms on combination with water inhibits the growth of mould, yeast and aerobic bacteria. As a chemical reducing agent it prevents the browning of fruits and vegetables due to enzymatic reaction (Lambrecht, 1995; Lozano-de-Gonzalez *et al.*, 1993; Weiss and Todd, 1992). It also has a notable effect on colour of raw red meat, causing it to lighten in colour, and being particularly effective on meat which has darkening by aerial oxidation. Thus, it can be used to reverse the visual effects of the initial deterioration and darkening of raw meat.

The addition of preservatives to foods is currently controlled by Regulations made or confirmed under the Food Safety Act 1990. These Regulations are revised from time to time as a result of changes in the requirements of the food trade or as result of new information on the effectiveness or effects of the use of the preservatives (FDA, 1996). The world food safety regulations allow the addition of specified preservatives, including sulphur dioxide to a variety of specified foods up to defined maximum limits.

Sulphur dioxide is a common preservative. It is added to food in the form of a gas (E220), in aqueous solution as sulphurous acid, as sodium sulphite (E221), sodium hydrogen sulphite (E222), Sodium metabisulphite (E223), potassium metabisulphite (E224), Calcium sulphite (E226) or as calcium hydrogen sulphite (E227). When used as preservatives in food, these chemicals are subject to purity criteria which are specified in the Regulations or in EEC Directives (FDA, 1996).

The current regulation specifies 61 classes of foods and food additives which are permitted to contain sulphur dioxide as a preservative, including hamburgers and similar products (FDA, 1996).

The permitted levels of sulphur dioxide preservative (Table 5) specify in the Regulations includes 15 milligrams per kilogram for grapes, 500 milligrams per kilogram for beer finings and 450 milligrams per kilogram for sausages, hamburgers and similar products (FDA,1996).

2.7.2 Nutritional and Medical Aspects of Sulphur Dioxide

Sulphur dioxide can be beneficial to the nutritional quality of some foodstuffs in that it assist in conserving vitamin C. However, it destroys the B vitamins and its use as preservative is therefore not recommended with fresh meats and other foods that are good sources of B vitamins, particularly thiamine (Whitaker and Lee, 1995). Although prolonged ingestion of such vitamin-depleted food would be needed before any health effects become apparent, there is concern about the vitamin content of the diet, particularly with children, and the sub-clinical effects of vitamin deficiency, on aspects such as intelligence (Watson, 1995).

Most people can only detect the presents of sulphur dioxide in the food by the taste when it is present in high concentrations, but certain individuals can taste (and object to) levels of the preservative within the range permitted in the foodstuff (Weller *et al.*, 1997).

Laboratory experiments with mince meat preserved with sulphur dioxide have demonstrated that cooking does not destroy all the preservative. However, some is liberated during cooking as gas, and this could give rise to respiratory problems, particularly with individuals who have an allergic reaction to sulphur dioxide.

2.7.3 Sensitivity to sulphur dioxide

Sulphur dioxide, at the levels permitted in food, will not affect most people. However, certain groups, particularly asthmatics, may be sensitive to this preservative.

People who are sensitive to sulphur dioxide usually get a burning sensation in the throat, tight chest, wheezing and sometimes respiratory distress.

Studies show that not all asthmatics will have a reaction after eating foods containing sulphur dioxide. The likelihood of a reaction depends on the type of food, its acidity, and the amount of sulphur dioxide and the sensitivity of the person. Consumers who are

sensitive to sulphur dioxide should avoid foods containing this preservative. This can be achieved by selecting foods, which do not declare sulphur dioxide on the label.

2.8 Food Labelling

The amount of sulphur dioxide permitted in foods and labelling requirements are detailed in the Australia and New Zealand Food Standards Code.

The ingredients of packaged foods must be listed on the label. A few foods do not require a full ingredient list to be declared on the package. However, if these foods contain more than 25 mg/kg of sulphur dioxide, the package must contain a statement declaring the presence of sulphur dioxide.

Sulphur dioxide can be carried over into the end product from food ingredients. For example, dried fruit may contain up to 3000 mg/kg of sulphur dioxide and when used as an ingredient in other foods may result in a low level of sulphur dioxide in the final product.

Sulphur dioxide is only permitted in certain foods at prescribed levels as specified in the code.

The table 5 lists foods that may contain sulphur dioxide with the maximum permitted level by food types.

Table 5: Maximum Permitted Level of Sulphur Dioxide for Some Food Types

Avocado spread, puree and pulp (frozen)	300mg/kg
Beer	25mg/kg
Brewed soft drink	115mg/kg
Cabbage, dehydrated	1500mg/kg
Carrots, dehydrated	1000mg/kg
Crystallised pineapple	280mg/kg
Desiccated coconut	50mg/kg
Dried fruits	3000mg/kg
Essences	230mg/kg
Fruit drink	115mg/kg
Fruit juice	115mg/kg
Fruit cordial, fruit syrup, fruit topping	230mg/kg
Fruit wine, vegetable wine, mead	
- With less than 5g/L residual sugar	200mg/kg
- With more than 5g/L residual sugar	300mg/kg
Glucose	
- Syrup	300mg/kg
- dried	40mg/kg
Imitation fruit	3000mg/kg
Low joule jams	285mg/kg
Mixed dried fruit	3000mg/kg
Soft drink	115mg/kg
Sausages	300mg/kg
Tomato juice, (pH less than 4.5)	
- Non-canned	115mg/kg
- Non-canned concentrate	400mg/kg
Vinegar	25mg/kg
- prepared from wine	100mg/kg
- Water-based iced confection mix	25mg/kg
Wine – less than 35g/L sugar	250mg/kg
Others	300mg/kg

(FDA, 1996)

2.9 Survey on Ministry of Food and Agriculture's Policy on Mango Fruits

The Ministry of Food and Agriculture (MOFA) is promoting selected non-traditional agricultural commodities for which Ghana is identified as competitive on the domestic sub-regional and international markets.

Crops identified for diversification and development as non-traditional commodities include pineapple, mango, papaya, chilli pepper and Asian vegetables. The advantage of this diversification is to accelerate economic growth, reduce poverty and minimize the countries vulnerability to external price shocks as a result of overdependence on a few traditional export commodities.

Interventions for improved production and marketing from the Ministry and other private sector players in the industry has resulted in substantial national economic growth over the last 5-10 years. The Horticulture Development Unit (HDU) of the Directorate of Crops Services, MOFA, has been on the forefront of this development providing technology to developing the industry.

MOFA is currently implementing various Projects aimed at addressing specific needs along the horticulture supply chain. These Projects include the Horticulture Exports Industry Initiative (HEII) of AgSSIP funded by the World Bank, Export Marketing and Quality Awareness Project (EMQAP) and the Millennium Challenge account (ACA)which augments the services of the HDU.

The HEII is a seven component integrated 2-year programme. The seven components through which support is given to the industry are;

1. Post harvest infrastructure development
2. MD2 pineapple sourcing and development
3. Innovative planting material sourcing and development
4. Food Safety and Quality Management
5. Industry Ownership and Farmer Equity Models
6. Strategic support systems and
7. Support to Mango out grower scheme

Under support to Mango out-growers scheme, the project has provided 2,000 out growers with a 50 % matching grant and technical support to access quality mango seedlings to establish and expand mango plantations in the Northern Region of Ghana.

Currently, there are several of the improved mango cultivars that are being cultivated in the country. However, the four suitable and exportable cultivars promoted by MOFA are Kent, Keitt, Palmer and Harden.

It is important to emphasise that, the experimenter's choice of the two prominent mango varieties namely Kent and Keitt for the studies was informed by the importance that MOFA attach to these cultivars as a policy.

2.10 The Dry Mango Fruits Processing Industry in Ghana

Dried fruits and other foods are tasty, nutritious, lightweight, easy-to-prepare, and easy-to-store and use. The energy input is less than what is needed to freeze or can, and the storage space is minimal compared with that needed for canning jars and freezer containers.

The nutritional value of food is only minimally affected by drying. Vitamin A is retained during drying; however, because vitamin A is light sensitive, food containing it should be stored in dark places. Yellow and dark green vegetables, such as peppers, carrots, winter squash, and sweet potatoes, have high vitamin A content. Vitamin C is destroyed by exposure to heat, although pre-treating foods with lemon, orange, or pineapple juice increases vitamin C content.

Dried foods are high in fibre and carbohydrate and low in fat, making them healthy food choices. Dried foods that are not well dried (below 10-12 percent moisture) are susceptible to mould.

In Ghana, mango fruits are primarily consumed in the fresh state usually as dessert and sometimes as a fruit drink or juices. Dried mango snacks are not popular desserts among many Ghanaians, however, in recent times it is gradually gaining some preferences among some section of the public.

Some African countries noted for the export trade in the dried mango fruit are Burkina Fasso, Uganda, Niger and South Africa.

Several drying systems are employed in the fruit processing industries. Some fruits are dried using direct solar drying, freeze drying, osmotic drying, vacuum tunnel drying and microwave drying just to mention some few. However, these dryer types

come with their cost and benefits and they do impact on the nutritional and sensory qualities of the processed fruits

In Ghana, Ebenut Ghana limited is the only Company involved in the production of dry fruits which are mainly exported to South Africa and some sold in some leading supermarkets in the country.

Previously, the method used in drying the mango fruits was solar drying process. However, as results of the poor quality of dried mango fruits realized from these dryers, a new dyer technology was introduced which is the butane powered dryer developed by the Swiss NGO (CEAS), Centre Ecologique Albert Schweitzer in Burkina Fasso.

The mango industry in Ghana is growing at a fast pace especially in the northern part of the country as a result of the excellent climatic conditions. It is expected that mango production is likely to increase in the near future and this calls for drying systems such as dehydration to extend the shelf life of these products and make them available all year round for local consumption and export.

Additionally, to cope with increased volumes of mango produce, there is the need to design efficient and simple drying systems that would meet the pocket of the ordinary farmer to acquire these dryers individually if they could afford them or corporately as a group.

Newly designed Solar and Gas cabinet dryers which are very simple and efficient have been designed by the Department of Biochemistry and Biotechnology (Food Science and Technology Section).

These drying systems were employed in the studies to access their effect on the nutritional composition and the sensory qualities of some mango cultivar fruits slices.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 INTRODUCTION

The experiment was carried out in the laboratories of the Department of Biochemistry and Biotechnology, Faculty of Science, KNUST. The study was on effect of drying methods on nutritional composition and sensory qualities of dehydrated sliced mango (*Mango indica L.)* pulp.

3.2 SOURCE OF RAW MATERIALS

Six commercial varieties of mangoes are currently produced in the country, and they are Keitt, Kent, Haden, Tommy Atkins, Palmer and Zill.

The Keitt and Kent varieties were used for the studies because they have tough skin, have little fibre and also have pleasant aroma. They were obtained from a commercial mango producing farm at Somanya in the Eastern Region of Ghana.

3.3 PROXIMATE ANALYSIS

3.3.1 Moisture Content (AOAC, 1990)

The fruits were peeled and the pulp removed from the seed with a sharp knife. In duplicates two grams of the pulp of each variety was weighed into a previously heated, dried, cooled and weighed crucible dish. The moisture crucible and its content were dried in a Gallenkamp hot air oven (model XOV 880, Gallenkamp Co. Ltd., England) at 105°C for 5 hours. The moisture crucible was then removed from the oven and cooled in a desiccator and the samples weighed. The crucibles with samples were then returned into the oven, dried, cooled and reweighed until a constant weight was obtained. Moisture content was expressed as percent fresh weight basis. A sample calculation of the moisture is shown in Appendix J.

3.3.2 Ash Content (Pearson, 1990)

Two gram samples of each variety were weighed in duplicates into previously ignited, cooled and previously weighed porcelain crucibles. The crucibles and their contents were placed in a Gallenkamp Muffle Furnace (model AS 260D Gallenkamp Co. Ltd., England) and heated to 600°C for two hours. The crucibles were removed, cooled and reweighed. The ash content was expressed on percent dry weight basis. See Appendix J for a sample calculation.

3.3.3 CRUDE FAT CONTENT (Pearson, 1990)

The free lipid content (neutral fats- triglycerides) of samples and free fatty acids can be determined by extracting the dried material with a light petroleum fraction in a continuous extraction apparatus. The solvent was distilled off and the extract was dried and weighed.

Crude fat was determined by transferring dried samples from the moisture determination into a thimble. A small ball of cotton wool was pushed into the thimble to keep the sample in place. A 250 ml round bottom flask was oven dried at 100° C and weighed. 150 ml petroleum spirit B. P. 60-80°C was then added to the flask and the apparatus set up. The sample(s) was refluxed for 4 hours on high heat on the heating mantle. The flask was removed after the 4 hours and the petroleum spirit evaporated on the steam bath. The flask and the oil was heated for 30 minutes in an oven at 103°C and later cooled in a desiccator. It was weighed and the weight of the oil was calculated. A sample calculation is shown in Appendix J.

3.3.4 Crude Fibre Content (Pearson, 1990)

Crude fibre consists of cellulose, hemicellulose and lignin. Lignin comprise of polymers of phenolic acids. Hemicellulose is made up of heteropolymers of polysaccharides.

Crude fibre was determined as loss in weight on ignition of dried residues remaining after digestion of defatted material with 1.25% H_2SO_4 and boiling1.25% NaOH. The percent crude fibre was expressed on dry weight basis.

Samples from the crude fat determination were transferred into 750 ml Erlenmeyer flasks and half gram of asbestos added. 200 ml of boiling 1.25% H_2SO_4 was then added to each flask and the flask was set on the hot plate as the condenser was

connected to the power source. It was timed for 30 minutes after which it was removed and filtered through linen cloth in funnel and washed with boiling water until washings were no longer acid.

The washed sample from the acid treatment was then returned into the flask with 200 ml boiling 1.25 % NaOH solutions using wash bottles calibrated to deliver 200 ml. The flask was connected to the condenser and boiled for another 30 minutes. It was removed and filtered through linen cloth and washed thoroughly with boiling water. The residue was transferred into a Gooch crucible and oven-dried for one hour at 100°C. It was cooled in a desiccator and reweighed. See Appendix J for a sample calculation.

3.3.5 Protein Content Determination (Pearson, 1990)

a) Digestion Process

Two grams of the two varieties were weighed in duplicates and 25 mls of concentrated H_2SO_4 were added to each sample and placed in digestion tubes and some quantity of selenium (catalyst) added and thoroughly shaken. The tubes were placed on a digestion burner and heated slowly until frothing ceased resulting in a clear solution. The tubes and their contents were cooled to room temperature. Each of the cooled digested samples was then transferred into a 100 ml volumetric flask and made to the mark with distilled water.

b) Distillation

The Kjeldahl distillation apparatus was flushed out with steam from boiling distilled water for about 10 minutes. 25ml of 2% boric acid and 2 drops of mixed indicator (4 ml of 0.1% methyl red solution and 20 ml of 0.1% bromocresol green solution in 95% alcohol) were poured into a 250 ml conical flask. The conical flask and its contents were completely immersed in the solution. Ten (10) mls of the digested sample solution was poured through the funnel into the decomposition flask. Twenty (20) mls of 40% NaOH solution was also added to the decomposition flask. The distillation apparatus was then switched on. The boric acid solution receiving the liberated ammonia changes colour to bluish green as soon as it comes into contact with the ammonia. The distillation was continued for about 5 minutes and the tip of the condenser was lowered into the boric acid. After distillation, the tip of the condenser

was washed with distilled water and the distillation continued for about 30 seconds again. The burner was then removed from the steam generator.

c) Titration

The distillate was titrated against 0.1N HCI solution. The acid was added from a burette to the distillate until the solution became colourless. The end point of the titration was observed when few drops of the acid added changed the colour of the solution from colourless to pink and the colour persisted for more than 10 seconds. The same procedure was followed for the blank except that the blank did not contain the sample.

d) Calculation

The crude protein content was calculated by multiplying the percentage total nitrogen obtained by a factor (6.25). A sample calculation is shown in Appendix J.

3.4 OTHER QUALITY CONTROL ANALYSIS DETERMINATIONS

3.4.1 Vitamin C Determination by Indophenol Method (AOAC, 2000)

(a) Principle

Aliquots of samples in oxalic acid solution are titrated with standardized sodium 2-6 dichlerophenol dye to a faint pink colour that persists for 5 to 10 seconds. This method is limited to juices of light colour because red pigments obscure the end point.

Reagents;

Indophenol dye 0.04 %

0.2 g of sodium 2, 6 dichlorophenolindophenol was weighed and dissolved in about 200 ml water.

Oxalic acid 0.4 %

4 g oxalic acid was weighed and dissolved in distilled water and made up to 1000 ml mark.

Standardization of dye

2 g of potassium iodide was weighed and dissolved in about 5 ml distilled water in 50 ml Erlenmeyer flask in triplicates. 15 ml of the dye was pipetted and added and then 10 ml 1 N HCl. This was mixed thoroughly and made to stand for 2 minutes. The

solution was titrated with freshly prepared 0.01 N sodium thiosulfate from a micro burette using 2 ml starch, until there is no change in colour when one drop or less is added.

(b) Procedure

Ten grams of each sample was weighed and this was macerated in a porcelain dish or motar. Twenty-five ml of distilled water was added onto the macerated sample to form a solution. Twenty ml of the solution was pipetted into 100 ml volumetric flask and this was made up to the mark with 0.4% oxalic acid and filtered through Whatman filter paper to clarify the solution. Ten ml of the filtrate (aliquot) was pipetted and 15 mls of oxalic (0.4 %) was mixed with the filtrate and this was titrated in a 50 ml Erlenmeyer flask with dye (0.04 %) to a faint pink end point lasting for 5 to 10 seconds. Titration was completed within one minute. A sample calculation can be found in Appendix J.

3.4.2 Vitamin A Determination (Underwood, 1984)

One gram of the samples was weighed into a porcelain mortar and macerated with 50 ml acetone added at gradual intervals until a fine paste was obtained. The mixture was filtered with a help of a sucking pump.

Twenty ml of petroleum spirit was then transferred into a washing macro burette and the filtrate added. The immiscible solutions were then flushed gradually with distilled water until a clear separation of the carotenoids was made with the distilled water when the carotenoids separation settled on the surface of the distilled water. The carotenoids were collected into a 50 ml beaker with a funnel containing gauze and anhydrous sodium sulphate to trap water in the carotenoid pigment after the distilled water was allowed to pass out from the burette. More petroleum spirit was added to the extract if it is deeper to give it to a known volume.

Total carotenoids were determined by Thermo Spectronic meter (model Genesys 10 UV, CAT335902 SN 2921136003).

Beta-carotene was determined by HPLC (MODEL LC-6A, NO. 277546KR) after a known volume of diluted samples was injected into the HPLC. The results were expressed as μg/100 g of the sample.The beta-carotene in the diluted fruits sample was run against predetermined beta-carotene standards.

3.4.3 Microbial Load (Pearson, 1990)

Two grams of each sample was weighed into 10 ml of distilled water in a sterile beaker and the content blended. Dilute nutrient agar solution was then prepared with distilled water and sterilized by autoclaving for 15 minutes .Appropriate serial dilutions of the stock solution were then prepared. One ml of each appropriate dilution was inoculated unto a malt extract agar using a pure plate technique. The plates were incubated at 37°C for 48 hours in a Gallenkamp illuminated incubator (model IH 285 Gallenkamp Co. Ltd., England). It was used to test for yeast and moulds micro-organisms.

Colonies (yeast and mould) developed were counted using a Gallenkamp colony counter (model CX 300 Gallenkamp Co. Ltd. England). Counts were expressed as log CFU/g. A sample calculation of the microbial load can be found in Appendix J.

3.4.4 pH (Pearson, 1990)

The pH was measured using a standardize Hanna pH meter (model pH 209).

Thirty grams of the sample was weighed into a kitchen blender and 90 ml of distilled water was added and blended .This was filtered through a Whatman paper with the help of a suction pump. The pH electrode was then washed with distilled water and dipped into the filtrate and the pH value read from the display screen on the pH meter.

3.4.5 Total Soluble Solids (AOAC, 1990)

Five grams of each sample was strained through a Whatman paper after it had been blended in a kitchen blender and the filtrate collected. Few drops of the filtrate were placed on a standardized hand held refractometer (model RF 012X, Stanley and Beckamp Co. Ltd., England) and the total soluble solids read as percent total soluble solids.

3.4.6 Iron (Fe) Determination

Five millilitres of concentrated HCL was added onto each of the samples after two grams of the sample had been ashed. This was filtered into a 100 ml volumetric flask with a Whatman filter paper and the filtrate made to the mark with distilled water.

The digested sample was analyzed by atomic absorption spectrometer (model Unicam 929 AAS, U. S.A) at 510 nm. The iron content was expressed as mg/100 g of dry matter.

3.4.7 Calcium (Ca) Determination

Calcium content of the sample was analyzed by atomic absorption spectrometry after two grams of the sample had been ashed and dissolved in five ml of concentrated HCL and filtered into 100 ml volumetric flask and 1ml of 0.5% $SrCI_2$. $6H_2O$ (Strontium Chloride) was added and made up to the mark with distilled water. Samples were analysed by atomic absorption spectrometer (model Unicam 929 AAS, U.S.A.) at 570 nm. The calcium content was expressed as mg/100 g of dry matter.

3.4.8 Potassium (K) Determination

The potassium content of the sample was analyzed using an atomic absorption spectrometer (model Unicam 929 AAS, U.S.A) at 767 nm after two grams of the sample had been ashed and dissolved in five ml of concentrated HCl and filtered into 100 ml volumetric flask with a Whatman filter paper and the filtrate made to the mark with distilled water. The potassium content was expressed as mg/100 g.

3.4.9 Magnesium (Mg) Determination

The magnesium content of the sample was analysed using an atomic absorption spectrometer (model Unicam 929 AAS, U.S.A) at 202.6 nm after two grams of the sample had been ashed and dissolved in five ml of concentrated HCL and filtered into 100 ml volumetric flask with a Whatman filter paper and filtrate made to the mark with distilled water. The magnesium content was expressed as mg/100 g.

3.5 Pre-treatment Application on Samples

The mango fruits (two mango varieties) were sliced to a slice thickness of 10 mm and were exclusively given four different pre-treatments conditioning namely; potassium metabisulphite solution pre-treatment, citric acid solution pre-treatment, sugar syrup blanching, lemon solution pre-treatment and control sample.

3.5.1 Potassium Metabisulphite Solution Pre-treatment

Soaking fruits in a solution of potassium metabisulphite has an effect on enzymatic browning reactions. Mixing potassium metabisulphite with water releases sulphur dioxide which penetrates the surface of the fruit retarding oxidation and enzymatic browning.

The fruit slices were soaked in 0.5 % solution potassium metabisulphite solution for one hour and this was based on preliminary work earlier done. After the stated duration, the fruit slices were removed, rinsed lightly under cold tap water and mopped on absorbent towel. The pre-treated slices were then dried in a solar drier.

3.5.2 Citric Acid Pre-treatment (CA)

Pure citric acid (or lemon juice) may also be used as an anti-darkening and anti-microbial pre-treatment. The fruit slices were soaked in 0.3 % citric acid solution for 45 minutes and this was also based on preliminary work done. When the process was completed, the fruits slices were removed and drained and mopped with a towel and then dried in a solar drier.

3.5.3 Sugaring by Soaking

Mainly used for fruits, the technique consists of soaking the product in concentrated sugar solution. The difference in concentration between the product and the solution leads to water migration from the least concentrated environment, i.e., the foodstuff, to the most, concentrated environment i.e., the sugar water.

The sugar solution was prepared by dissolving 700 g sucrose in 1 litre water (70° Brix) and the fruit slices soaked in the solution for 45 minutes. The fruits were later removed and mopped with a dry towel and dried in a solar drier.

3.5.4 Lemon Juice Pre-treatment

A solution of 0.3 % lemon juice was prepared and the fruit slices soaked in the solution for 45 minutes. The fruit slices were removed and mobbed with a dry towel and dried in a solar drier.

3.5.5 Control Sample

Aside all the pre-treatment methods, a control was also carried out. The fruit slices were dried without any pre-treatments in both the solar and the gas oven drier. (Photographs of both solar and gas driers are shown in figures 5 and 6 respectively).

3.6 Preparation of Sample, Pre-treatment and Drying of Sample

Fresh ripe and healthy mango fruits namely Keitt and Kent varieties were obtained from a plantation at Somanya in the Eastern Region. The fruits were then sorted out, washed under running tap water and cleaned with a clean dry towel. The peel was then removed using a stainless steel knife. The fruit was halved longitudinally at both flat portions of the seed and the resulting fresh pulp was then sliced into thickness of 10 mm.

The sliced fruits were then given some pre-treatment conditions and arranged on a clean dry tray in single layers and immediately dried in a solar drier at temperature range of 30-55°C and wooden gas cabinet drier at temperature range of 52-54°C. (Refer to figure 1 for sample preparation for solar drying and figure 2 for sample preparation for gas oven drying).

Figure 1: Flow Chart for Solar Drying of Mango Fruits

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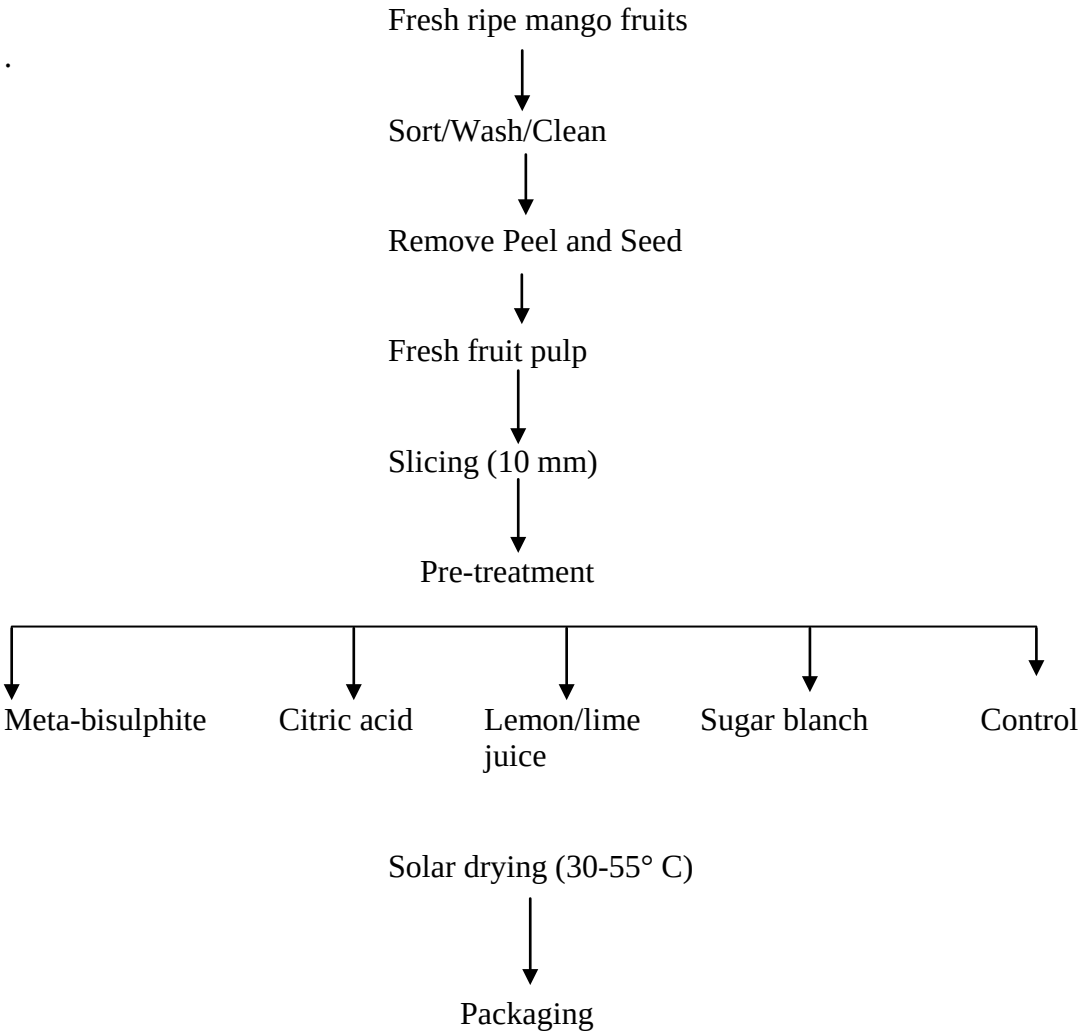
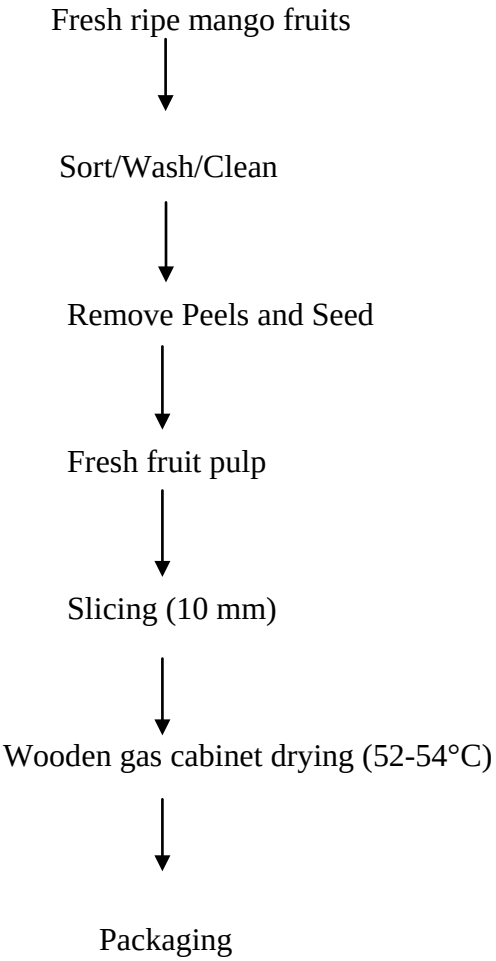


Figure 2: Flow Chart for Wooden Gas Cabinet Drying of Mango Fruits



Dimensions of the various dryers used for the studies

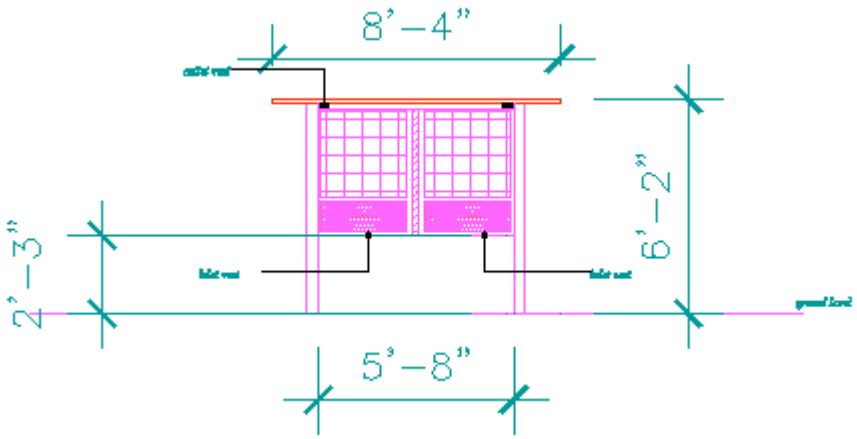


Fig. 3.1a: Front view of solar cabinet dryer

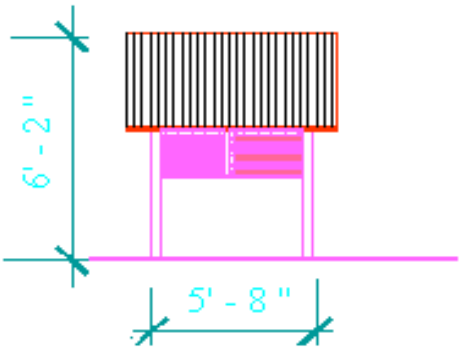


Fig. 3.1b: Back view of solar cabinet dryer

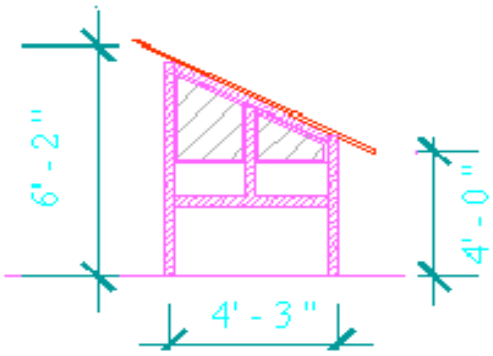


Fig. 3.1c: Side view of solar cabinet dryer

The main parts of the solar cabinet dryer were a solar collector (Perspex) and drying chambers with glass wells. The solar cabinet dryer consist of a Perspex roof (tilted at 15° to the horizontal) and wooden cabinets fitted with rollers for easy removal and inspection of samples. An insulation material (latex) was use to fill the gaps in-between the top frame and the roof to reduce heat losses. A glass partition divides the main cabinet into 2 compartments. Each compartment, which heats up independently of the other, had four movable cabinets with wire mesh base of dimension 0.75 m x 0.62 m each. Each compartment had three adjustable inlet vents. The dimensions of the dryer are shown in Fig.3.1a -3.1c.

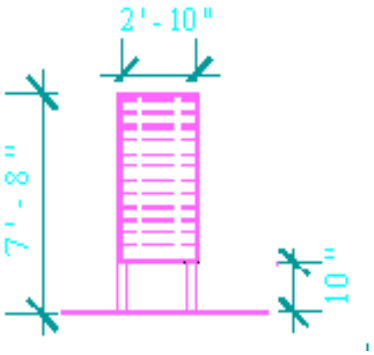


Fig. 4.1a: Front view of gas dryer

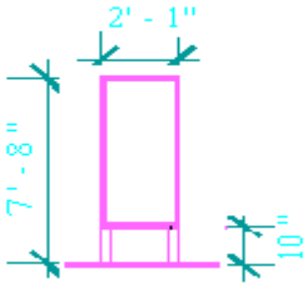


Fig. 4.1b: Side view of gas dryer

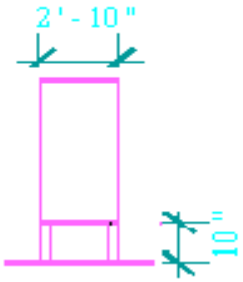


Fig. 4.1c: Back view of gas dryer

The biogas dryer consist of a wooden chamber with wooden legs as stand, a compartment (at the base) for housing the burner, and a single door serving as the main door. The drying compartment had 10 movable trays (0.72 m x 0.45 m) with mesh base. The walls of the chamber were double layered and had an air gap of 0.02m thick in-between. The dimensions of the dryer are shown in Fig. 4.1a – 4.1c.

Fig 5 Solar dryer

Fig. 6 Gas dryer

3.7.1 Quality Control Analytical Measurement

The mango fruit slices were analyzed for certain quality attributes such as moisture content, microbial load (yeast and mould), and vitamin C and pro-vitamin A soon after the drying period.

3.7.2 Experimental Design and Statistical Analysis

A complete random design of two factors (varieties) comprising of five pre-treatment methods was employed for the study for the solar drying method and a CRD of two factors for the wooden gas drier. Statistical package used for the studies was the Stat graphics (Centrion edition).

3.7.3 Sulphur Dioxide Determination (Pearson 1970)

Twenty grams of each sodium metabisulphite pre-treated dried mango samples were weighed into a porcelain mortar. The samples were macerated with 50 ml of 10% ethanol solution. The mash was then transferred into a 200 ml beaker and mixed thoroughly with about 50 ml of 10 % ethanol solution. Ten ml of the filtrate was pipetted into a 300 ml Erlenmeyer flask. Twenty-five ml of sodium hydroxide (10%) was added, mixed and stoppered with a cork. The flask was allowed to stand for 15 minutes. Ten ml of sulphuric acid (3 parts water to 1 part concentrated sulphuric acid) and 5 ml of starch as indicator were added. The mixture was then titrated to a permanent blue colour with 0.02 N iodine solutions. Sulphur dioxide content in the dried sample mango was expressed as parts per million (ppm) on dried weight. A sample calculation is shown in Appendix J.

3.8 Sensory Evaluation

The sensory properties of the pre-treated dried mango samples were determined using 50 sensory panellists. Twenty of the panellists consisted of females and the others were males and they range between the age brackets of 23-35 years. They were students and workers from the Kwadaso Agricultural College, Kumasi and they were people familiar with mango products.

The dried samples were served in random order and the attributes that were looked out for were colour, flavour, texture and overall acceptance. The panellists were to assign scores to indicate their preference for the various attributes using 9 point hedonic scale from 1, 2,3,…… 8 and 9 representing dislike extremely, dislike very

much,… liked very much and liked extremely respectively. The responses were presented on a bar graph and analyzed statistically.

3.9 The Effect of Packaging and Storage Time on the Quality of the Dried Mango

3.9.1 Experimental Design and Statistical Analysis

The experimental design employed for the study was a complete randomized block design (CRBD) of two factors (varieties) consisting of three packaging forms namely; low density polyethylene packs as control (P2) high density polyethylene packs (P1) and polypropylene packs (P3) and 4 months storage times with the two mango varieties as blocks. Analysis was carried out in duplicates for moisture, microbial load, vitamins C and pro-vitamin A and the result obtained was statistically analysed using ANOVA. Statistical package used was the Stat graphics (Centrion edition).

3.9.2 Sample Selection and Packaging

The best products from each of the two drying methods namely pre-treated samples from the solar dryer and samples from the gas dryer that were selected during the sensory evaluation and used for the packaging and the shelf-life studies. The selected products were gradually cooled and packaged for permanent storage. They were stored at room temperature in a cool and dry environment.

The packaging materials used for this study were as follows;

1. High density polyethylene packs, control (P1)
2. Low density polyethylene packs (P2)
3. Polypropylene packs (P3)

3.9.3 Quality Control Analysis Determinations

Quality analysis was carried out monthly for a period of four months on the three storage types or packaging materials on the following quality indices; moisture, microbial load (yeast and mould) vitamin C and pro-vitamin A contents.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 The effect of Pre-treatments on Moisture with drying time

There was a general decrease of the moisture content for Keitt and Kent mango varieties during solar drying. The results of solar drying are shown in (Appendix H Table 6 and Figures 7 and 8 respectively).

For Keitt mangoes the decrease in moisture was from 80.84 % to 14.89 %, 13.88 %, 15.90 %, and 14.39 % respectively for PMS, CA, SS and LEM pre-treatment whiles the control had moisture content of 13.74 %. Kent mango decreased from 82.78 % to 14.89 %, 14.27 %, 16.32 % and 15.63 % while the control had 14.20 %.

The drying time and water loss was quiet significant for the various pre-treatment types of samples. Water loss was higher with respect of the control samples for the two mango varieties since they did not undergo any pre-treatment. For Keitt mango variety, a period of 96 hours (4 days) was required to reduce the moisture content to 13.74-15.90 % for the various pre-treatments whiles Kent mango variety took 96 hours (4 days) to reduce the moisture content to 14.20-16.32 %.

Sugar syrup (SS) pre-treatments had the highest moisture content indicating that it had the lowest moisture loss among the other pre-treatment methods for each of the two mango varieties. The higher moisture content observed with the sugar pre-treatment samples could be attributed to the presence of dissolved solids contributed by the sugar treatment thus decreasing the water vapour pressure in the product hence lowering drying rates (Dennis, 1993). Also, the hygroscopic nature of the sugar could influence the final moisture content of the dried product by lowering the rate of drying in the pre-treated samples. In addition crystallization of these solutes especially sugars could minimize the rate of heat transfer during drying (Mazza and LeMaguer, 1980).

There was no significant difference $p > 0.05$ between the two mango varieties with respect to moisture content.

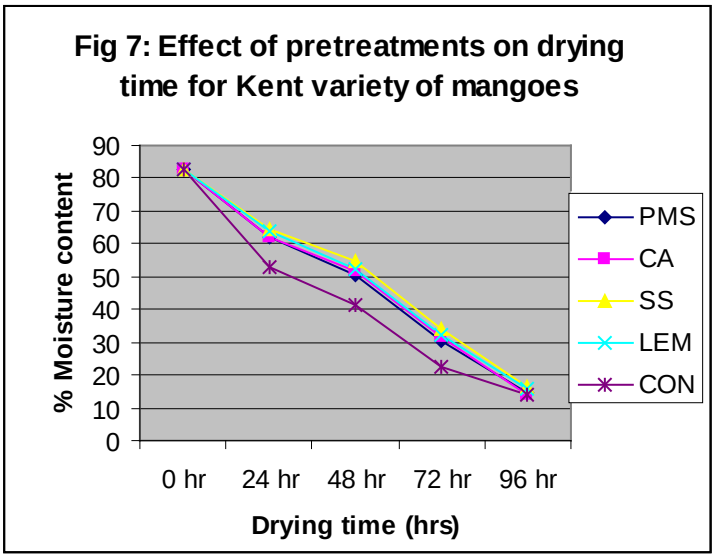


Fig 7: Effect of pretreatments on drying time for Kent variety of mangoes
% Moisture content
90
80
70
60
50
40
30
20
10
0
0 hr
24 hr
48 hr
72 hr
96 hr
Drying time (hrs)
PMS
CA
SS
LEM
CON

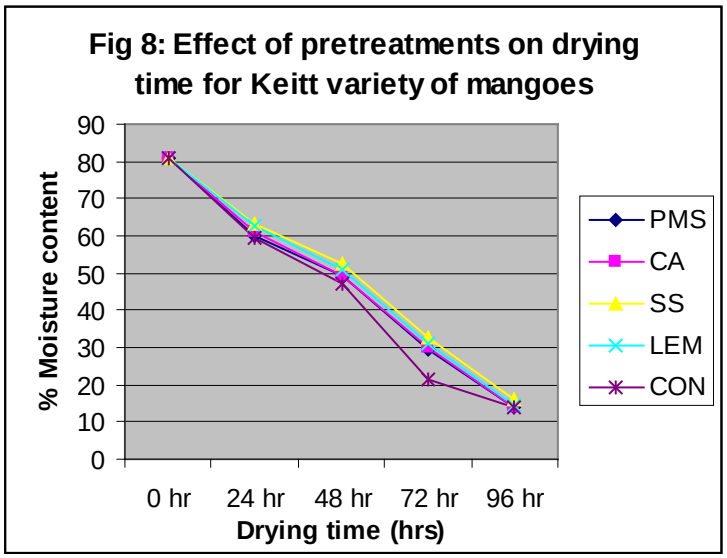


Fig 8: Effect of pretreatments on drying time for Keitt variety of mangoes
% Moisture content
90
80
70
60
50
40
30
20
10
0
0 hr
24 hr
48 hr
72 hr
96 hr
Drying time (hrs)
PMS
CA
SS
LEM
CON

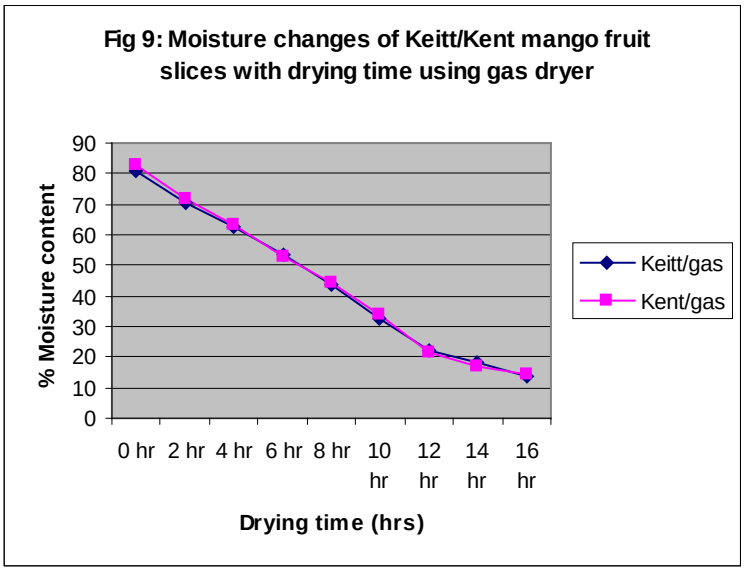
4.2 Moisture changes of Keitt/Kent Mango Fruits with drying time using Gas Cabinet Dryer

There was a general decrease in the moisture in the gas drying method for both varieties after 16 hours of drying time (Appendix H Table 7 and Fig. 9).

For Kent (gas) and Keitt (gas), moisture content reduced from 80.78 % to 14.14 % and 78.84 % to14.01 % respectively after 16 hours of drying time.

The drying time and water loss was significant for gas drying methods for both mango varieties. At the end of 16 hrs, moisture content for gas dried mangoes had attained the required moisture content of 12-16 percent for the two mango types. There was significant loss of moisture between the 0 and 12 hrs. However, after 12 hours, equilibrium condition had almost been attained.

Comparing the two methods of drying, the drying time and water loss was lower for both mango varieties using solar dryer as compared to the gas dryer. After 16 hours of drying time, the moisture content of the solar dried products was 41.82 % for Kent and 41.27 % for Keitt mangoes. There was however, no significant difference in the moisture content of the Kent and Keitt mangoes for gas drying method.



4.3 Moisture changes of Keitt/Kent Mango Fruits with drying time using Solar Cabinet dryer

Moisture decreased generally for the two mango varieties using the solar cabinet dryer after 96 hours (4 days) of drying time to reduce the moisture content to the required of 12-16 percent (Appendix H Table 8, Fig. 10).

For Keitt (Solar) and Kent (Solar) moisture content for the fresh and dried samples was in the range of 80.84 % to 13.74 % and 82.78 % to 14.20 % respectively.

Comparing the two drying systems that are the solar cabinet and the gas cabinet dryers, it was realised that the drying time and water loss was much faster for gas drying method for both mango varieties.

Drying time and water loss using solar dryer was lower for both mango varieties as compared to the gas dryers. After 16 hrs of drying time, the moisture content of the solar products was 41.82 % for Kent and 41.27 % for Keitt mango fruits.

There was however, no significant difference in the moisture content of the Kent and Keitt mangoes for solar drying method.

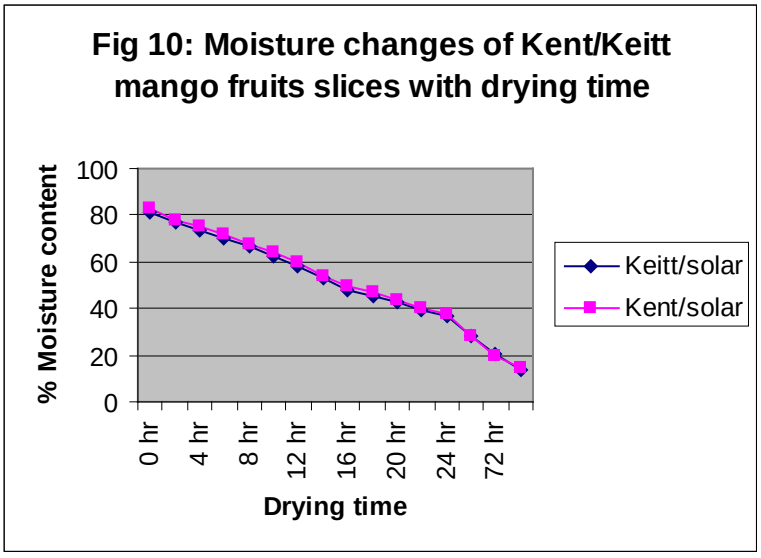


Table 6: Proximate and Nutrient Composition of Keitt and Kent Mango Fruits

Parameter	Keitt Variety	Kent Variety	Literature range
% Moisture content	80.84 ± 0.90	82.78 ±0.48	78- 89
% Ash content	0.63 ± 0.06	0.51 ±0.06	0.2-0.9
%Crude fibre	1.76 ± 0.06	2.06 ±0.06	0.3-3.2
%Crude protein	1.09 ± 0.06	1.31 ±0.06	0.2-2.1
%Crude fat	0.07 ± 0.06	0.04 ±0.06	0.2-1.0
%Carbohydrate	15.61	13.29	16.9
Total Energy (Kcal)	67.43	58.76	50-63
Vitamin A (µg/100g)	260.15 ± 0.00	170.24 ±0.00	400-800
Vitamin C (mg/100g)	25.42 ± 0.19	27.25 ±0.68	2.90-136.50
pH	3.81 ± 0.00	3.81 ±0.00	3.80-4.09
% Total sugars	15 ± 0.00	15 ±0.00	9.28-20.90
Calcium (mg/100g)	14.40 ± 0.06	11.80 ±0.06	3-37
Potassium(mg/100g)	42.77 ± 0.06	38.57 ±0.06	10-205
Magnesium(mg/100g)	8.32 ± 0.06	8.51 ±0.06	10-17
Iron(mg/100g)	1.17 ± 0.00	1.06 ±0.06	0.33-1.03

Source: USDA Nutrient Data base; Nanjundaswamy (1991).

The results of the proximate compositions showed that moisture content of the mango varieties were 82.78 % for Kent and 80.84 % for Keitt, (Table 9). However, the difference in the moisture content of the mango varieties were significant ($p<0.05$). This difference could be attributed to the stage of fruit before processing. The stage of ripeness of the fruit before processing normally depends on the anticipated final product (Chan *et al.,* 1979). Litz (1997) reported moisture content of 78 -89 % for most fresh ripe mango fruits. The high moisture content mango fruits are therefore highly recommended for juice extraction as at this time more cell structure might have been broken down to give a higher yield of juice. However, fruit meant for drying are required to be firm and have a lower moisture content to keep the shape of the final dried product.

The results also showed a significant difference ($p<0.05$) in the ash content between the two mango varieties. The Kent variety had an ash content of 0.51% whilst the Keitt variety was 0.63%. The differences in the ash content could be attributed to cultural practices and the growing medium of the two varieties. Peterson *et al.,* (1982) reported that the chemical nature of the growing medium can have a significant effect

on the ash content and mineral content of the fruit. The higher ash content of the Keitt variety gives an indication that it was grown in a mineral rich soil.

Crude fibre and crude protein for the two varieties also revealed significant differences ($p<0.05$). The differences could be due to cultivar and management practices.

For vitamin A, the results showed a significant differences ($p<0.05$) between the Keitt and the Kent varieties. Differences are largely attributable to cultivar/varietal differences. However, the stage of maturity, post-harvest handling, processing and storage conditions, growing conditions such as climate, soil fertility and stage of ripeness can also bring about differences in the vitamin A content among mango varieties.

Vitamin C content also showed a significant difference between the two varieties with Kent having a value of 27.25 mg/100 g and Keitt 25.42 mg/100 g. The content of vitamin C in fruits and vegetables can be influenced by various factors such as genotype differences, pre-harvest, climatic conditions, cultural practices, maturity and harvesting methods and post harvest handling procedures (Lee and Kader, 2000). The higher the intensity of light during the growing season, the higher the vitamin C content in plant tissue. Nitrogen fertilizers at high rates tend to reduce the vitamin C content in many fruits and vegetables. Vitamin C content of many crops can be increased with less frequent irrigation (Lee and Kader, 2000). Temperature management after irrigation is the most important factor to maintain vitamin C in fruits and vegetables. Losses are high at high temperatures and with longer storage duration. Processing methods and cooking methods can result in significant losses of vitamin C (Fennema, 1996).

The result of the mineral content also showed a significant difference ($p<0.05$) between the two mango varieties with respect to calcium and potassium. However, magnesium and iron content had no significant difference between the varieties. The calcium content was 14.40 mg/100g (Keitt) and 11.80 mg/100g (Kent). The potassium content was 42.77 mg/100g (Keitt), and 38.57 mg/100g (Kent). Magnesium content

was 8.32 mg/100g (Keitt), and 8.51 mg/100g (Kent). The iron content was 1.17 mg/100g (Keitt) and 1.06 mg/100g (Kent).

The result further showed that there were no significant differences ($p > 0.05$) with respect to total soluble sugars (TSS) and the pH.

From the result presented in Table 9, it could be concluded that the compositional analysis carried out for the two mango varieties mostly conformed to the ranges of references cited.

4.4 Effect of some Pre-treatment Methods on the Quality of Solar dried Mango Fruits

The moisture content of the dried mango fruit slices ranged from 13.74 – 15.90% and 14.14 – 16.32% for Keitt and Kent mango varieties respectively. The control (Con) dried fruit sample had moisture content of 13.74 % (Keitt) and 14.20 % (Kent), (Appendix H Table 10, Figs. 11-16).

Some of the pre-treatments significantly ($p<0.05$) affected the moisture content of the pre-treated dried mango fruit samples with sugar syrup treatments having higher moisture contents of 15.90 % (Keitt) and 16.32 % (Kent) than the other treatments.
The LSD for the moisture content by the Duncan multiple test revealed that there was no significant difference ($p>0.05$) among the citric acid, potassium metabisulphite pre-treatment and the control. There were also no significant difference ($p>0.05$) between the citric acid and the lemon pre-treatment. However, the LSD showed that there was significant difference ($p<0.05$) between the sugar syrup pre-treatment from the other treatments (Appendix 2B).

The moisture content followed a trend of sugar syrup (SS)>lemon (LEM)>potassium metabisulphite (PMS)>citric acid (CA)> control (CON) in that order (Appendix H Table 10, Figure 11). There was no significant difference ($p>0.05$) between the two types of mango varieties with respect to moisture content.

The higher moisture content observed with the sugar pre-treatment could be attributed to the presence of dissolved solids contributed by the treatment thus decreasing the

water vapour pressure in the product hence lowering the drying rates (Dennis, 1993). Also, the hygroscopic nature of the sugar product could influence the final moisture content of the dried fruits by lowering the rate of drying in the sugar pre-treated sample. In addition, possible crystallization of these solutes especially sugars could minimize the rate of heat transfer during drying (Mazza and LeMaguer, 1980).

Pre-treatment methods had a significant difference ($p<0.05$) on the ash content of the dried mango fruits, (see Appendix B). The ash content ranged from 0.27 – 0.51 % and 0.23 – 0.45 % dry weight for both Keitt and Kent mango types respectively (Appendix H Table 10, Figure 12).

The Keitt variety samples had higher ash content than the Kent variety. These differences were significant ($p<0.05$) and could be attributable to their varietal differences and cultural practices. Use of fertilizers and differences in soil fertility can result in differences in the composition of the ash content of crops (Dennis, 1993).

The LSD for the ash content by the Duncan multiple test showed that no significant differences ($p>0.05$) exist between the control and lemon treated and between the lemon treated and sugar syrup treated dry fruit samples.

LSD also showed no significant differences ($p>0.05$) between the sugar pre-treated dry fruit, citric acid treated and potassium metabisulphite treated dry fruit, (Appendix 2B).

Pre-treated PMS samples had a higher ash content followed by CA, SS, LEM and CON in that order. The high ash content of PMS samples could be attributed to the presence of potassium in the metabisulphite (Dennis, 1993).

Pre-treatment methods had no significant effect ($p>0.05$) on the crude fibre content of the dried samples. However, the control dried fruit samples had higher crude fibre content than the other treatments. Generally, pre-treated samples had lower crude fibre content than the control. The results showed a range between 0.75 – 0.93 % dry weight and 0.57 – 0.72 % dry weight for Keitt and Kent mango respectively, (Appendix H Table 10, Figure 13). However, significant effect ($p<0.05$) was

recorded between the two mango varieties. These differences could be attributed to varietal variations.

The effect of pre-treatment on the crude fibre (cellulose and lignin) of fruits and vegetables has not been fully understood. However, studies have shown that, the formation of digestion resistance starch as a result of dehydration and/or browning (phenolics) and which are analysed as lignin (phenolics) may influence the measurement of crude fibre in the dried fruits product. This could account for the higher crude fibre content of the control and lemon treated samples.

The lower crude fibre content in the PMS treatment is a strong indication of inhibition of browning reaction as compared to the other pre-treatments in the order of PMS>CA SS>LEM>CON. The control had undergone some browning as compared to the other pre-treatments types.

The results showed vitamin C content of the pre-treated samples range between 13.74 – 16.80 mg/100 g dry weight and 15.06 – 18.08 mg/100 g dry weight for Keitt and Kent mango varieties, respectively (Appendix H Table 10, Figure 14).

The results showed that pre-treatment had significant effect ($p<0.05$) on the vitamin C content. The potassium metabisulphite (PMS) pre-treated sample had higher vitamin C content retaining 63.50 % and 66.35 % for Keitt and Kent varieties respectively. The control samples retained the least amount of vitamin C of 54.05 % and 55.27 % respectively for Keitt and Kent mango samples, (Appendix 2B). The vitamin C content of the pre-treated samples followed a trend of PMS>CA>SS>LEM>CON for both varieties.
There was also a significant difference ($p<0.05$) between the two mango varieties. Kent mango had higher vitamin C content than the Keitt mango due to their varietal differences.

Sapers and Miller (1992, 1993, and 1995) in their studies on pre-treatment methods reported that citric acid and sulphite prevents the oxidation degradation of vitamin C to other dehydroascorbic acid derivatives by scavenging oxygen and sulfite undergoing oxidation to form sulphates. Citric acid provides a low pH which inhibits enzymatic degradation of vitamin C. Higher sugar concentration has also been

reported to prevent vitamin C reduction during drying of fruit and vegetables (Salunkhe *et al.*, 1991; Vamos- Vigyazo, 1981).

For pro-vitamin A, the result indicated that there was significant difference ($p<0.05$) between the two mango varieties. Keitt variety had higher pro-vitamin A content than the Kent due to its peculiar varietal characteristics (Appendix H Table 10, Figure 15). However, there were significant differences ($p<0.05$) in the pre-treatment methods for both varieties (Appendix 2B). The pro-vitamin A content range from 94.12 -145.21 mg/100 g dry weight for Keitt and 72.51- 96.41 mg/100 g dry weight for Kent. Potassium metabisulphite (PMS) pre-treated samples retained a higher pro-vitamin A content of 55.82 % and 56.63 % for Keitt and Kent mango samples whilst the control samples retained the lowest amount of 36.13 % and 42.60 % respectively for Keitt and Kent mango samples. The pro-vitamin A content of the pre-treatment types followed a trend of PMS>CA SS>LEM>CON for both varieties.

Vitamin A and C are antioxidant that plays a major role in disease control most importantly cardiovascular diseases. Vitamin A is an essential nutrient required for normal growth, reproduction, vision and immune health. Vitamin C is necessary for normal collagen synthesis and deficiencies result in collagen breakdown and the disorder scurvy.

It has also been reported that vitamin A deficiencies is a major public health problem in Ghana and especially in the northern part of the country (Benamba, 2005).
At a time when these deficiencies are severe in the north, mango fruits are in abundant in the north and southern part of the country.
Processing fresh mango fruits into dehydrated slices and packaging these in the above packaging materials by farmers in the north would go a long way to address the vitamin A and C deficiencies problems in the country and especially in the north.

Results of the effect of pre-treatment methods on the microbial load (yeast and mould) of the dried samples ranged from 44 -80 cfu/g dry weights for Keitt mango and 45 – 85 cfu/g dry weight for Kent mango variety, (Appendix H Table 10, Figure 16).

Pre-treatment had significant differences ($p<0.05$) on the microbial load of the dried products. However, there was no significant difference ($p>0.05$) between the two mango varieties.

Pre-treatment had significant effect ($p<0.05$) on the microbial load of the dried mango products, (Appendix 2B). Potassium metabisulphite (PMS) had greater effect in the reduction of microbial load.

Sulphites have been reported to exhibit a greater microbial effect in food processing. However, the low water activity also contributed to lowering the microbial load in a synergistic or combined effect (hurdle technology) (Alzamora *et al.,* 2000). The high sugar concentration used as a pre-treatment also accounted for the low microbial load in sugar pre-treated samples. Leistner, (1994) reported that concentrated sugar solutions (50% and above) creates an osmotic pressure and lowers the water activity in which the microbes lost water to their environment, in effect inhibiting microbial growth. Citric acid has also been reported to have a great effect on microbial load reduction by lowering the pH to a critical point that inhibits growth (Gould, 1983). All pre-treatments had a significant effect ($p<0.05$) in reducing the microbial load compared to the control. The residual sulphur dioxide content of the potassium metabisulphite pre-treated samples were 150 mg/kg for Keitt mango and 152 mg/kg for Kent mango. These levels fall below the permitted international standards of 3000 mg/kg (Weller, *et al.*, 1997).

Fig:11 Effect of pretreatment on the moisture content of solar dried mango fruits

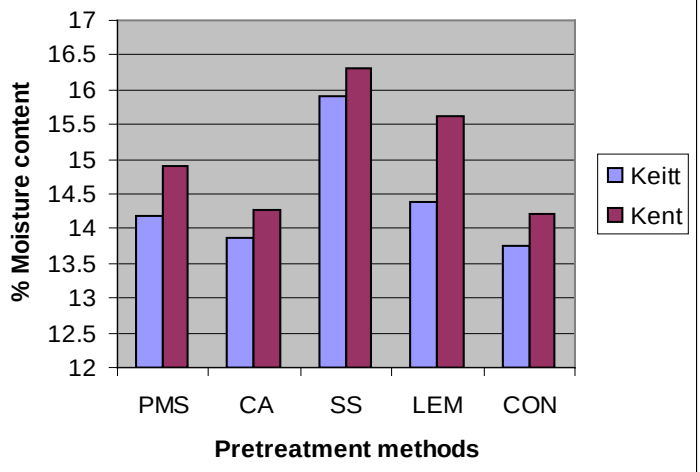


Fig12: Effect of pretreatment on the ash content of solar dried mango fruits

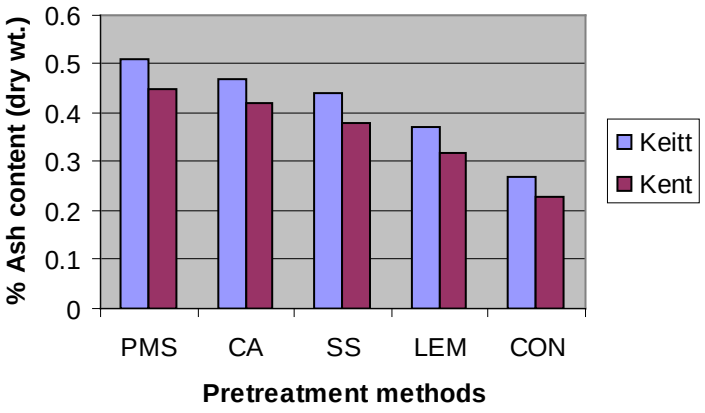


Fig 13: Effect of pretreatment on the crude fibre content of solar dried mango fruits

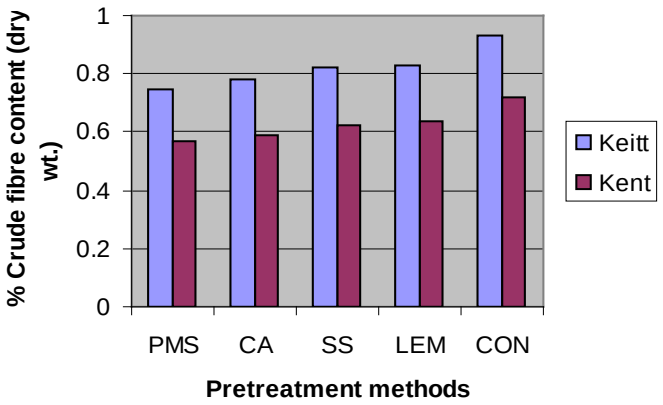
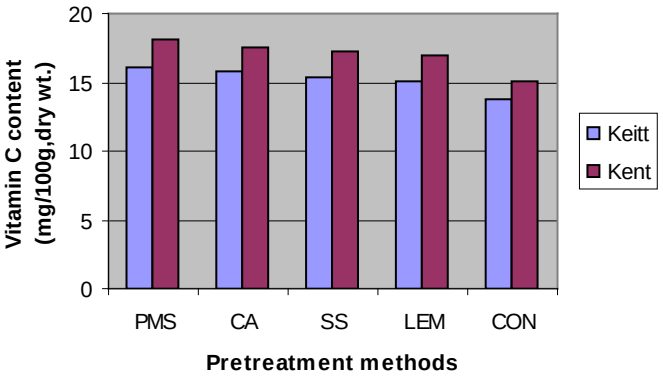


Fig 14: Effect of pretreatment on the vitamin C content of solar dried mango fruits



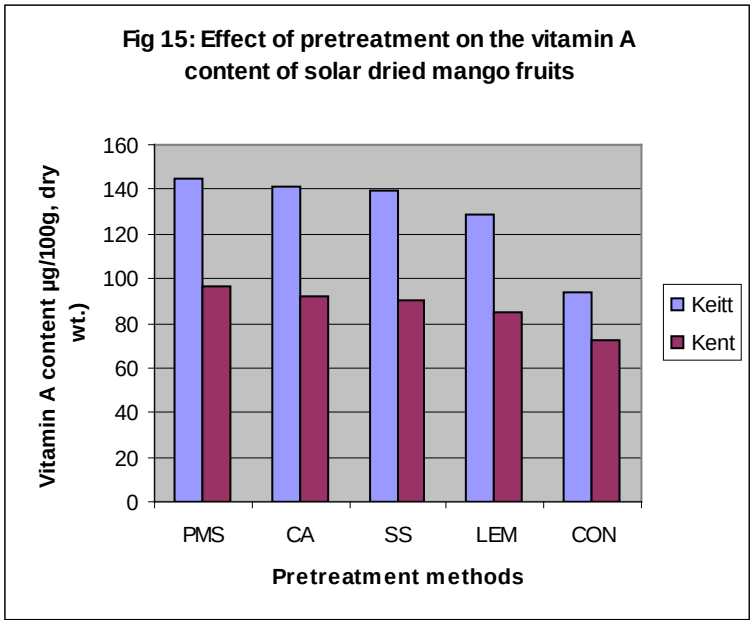


Fig 15: Effect of pretreatment on the vitamin A content of solar dried mango fruits
Vitamin A content µg/100g, dry wt.)
160
140
120
100
80
60
40
20
0
PMS
CA
SS
LEM
CON
Pretreatment methods
Keitt
Kent

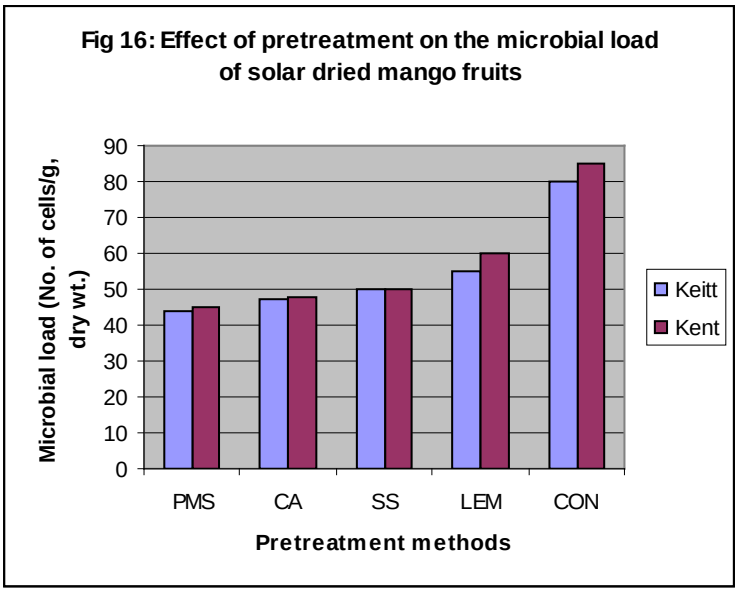


Fig 16: Effect of pretreatment on the microbial load of solar dried mango fruits
Microbial load (No. of cells/g, dry wt.)
90
80
70
60
50
40
30
20
10
0
PMS
CA
SS
LEM
CON
Pretreatment methods
Keitt
Kent

4.5 Effect of Solar and Gas Cabinet Dryers on the nutritional composition of Mango Fruits

Results of the two drying methods showed that there was no significant difference ($p<0.05$) in the moisture content of the two mango varieties (Appendix 2C).
There was also no significant difference ($p< 0.05$) in the moisture content with respect to the drying methods for each of the two varieties, (Appendix 2C).

There was significant difference ($p<0.05$) on the ash content for the drying methods for the Keitt and Kent varieties. For Keitt, the lowest ash content was 0.27 % and the highest was 0.55 % for solar cabinet and gas cabinet drying respectively, (Figure 18, Appendix H Table 11).
For Kent, 0.23 % was the lowest and 0.46 % the highest for the ash content with respect to solar cabinet and the gas cabinet dryers. However, there was no significant difference ($p< 0.05$) in the ash content for the two varieties, (Appendix 2C).

Drying types had no significant effects ($p<0.05$) on the crude fibre content of the two mango varieties. However, there was a significant difference ($p <0.05$) in the crude fibre contents of the varietal types (Appendix 2C). These differences could be attributable to their varietal differences. The highest crude fibre recorded for the Keitt variety was 0.96 % and the lowest was 0.93 % for solar and gas cabinet drying. For Kent, the lowest crude fibre recorded was 0.72 % and the highest 0.74 % for solar and gas cabinet drying methods (Figure19, Appendix H Table 11).

Drying methods had significant effects ($p<0.05$) on both vitamin C and pro-vitamin A contents of two mango varieties. However, the differences in the vitamins C and pro-vitamin A contents of the mango types arising as a result of the drying methods could likely be due to the faster drying period and sustained temperature observed in the gas cabinet dryer as compared to the longer drying period and irregular temperature observed in the solar dryer.

Highest values for vitamins C and pro-vitamin A were recorded for the Keitt variety with respect to the drying methods was achieved in the gas cabinet dryer 16.80 mg/100 g and 151.46 μg/100 g respectively whilst the lowest was recorded in the solar cabinet drying13.74 mg/100 g and 94.12 μg/100 g. The amount of vitamin C

retained for gas drying method for Keitt mango samples were 66.08 % and 58.22 % for pro-vitamin A whilst for solar drying, 54.05 % and 36.13 % were retained respectively for vitamins C and pro-vitamin A. For the Kent variety, highest values of vitamin C and pro-vitamin A achieved with respect to the drying methods was recorded also in the gas cabinet dryer with values of 18.82 mg/100 g and 100.29 µg/100 g corresponding to vitamins C and retention of 69.06 % and 58.91 % respectively. The lowest values of 15.06 mg/100 g and 72.51 µg/100 g for solar cabinet drying corresponds to vitamins C and pro-vitamin A retention of 55.27 % and 42.60 % respectively for Kent mango samples.

The results of the effect of drying methods on the microbial load (yeast and mould) of the dried samples showed a significant difference ($p<0.05$). There was also a significant difference ($p<0.05$) between the mango types (Appendix 2C).The lowest microbial load occurred in the samples dried in the gas cabinet dryer with a value of 36 cfu/g dry weight for Keitt and 40 cfu/g dry weight for Kent mango .The highest microbial population was recorded for samples in the solar cabinet dryer with 80 cfu/g dry weights for Keitt and 85 cfu/g dry weights for Kent mango types respectively (Figure 22, Appendix H Table 11).The gas dryer had a greater effect in minimizing the microbial load due to the combined effect of the low water activity and the high temperature short time (HTST) drying mechanism. Differences in the water activities of the dried mango types accounted for their variations in the microbial population of the samples.

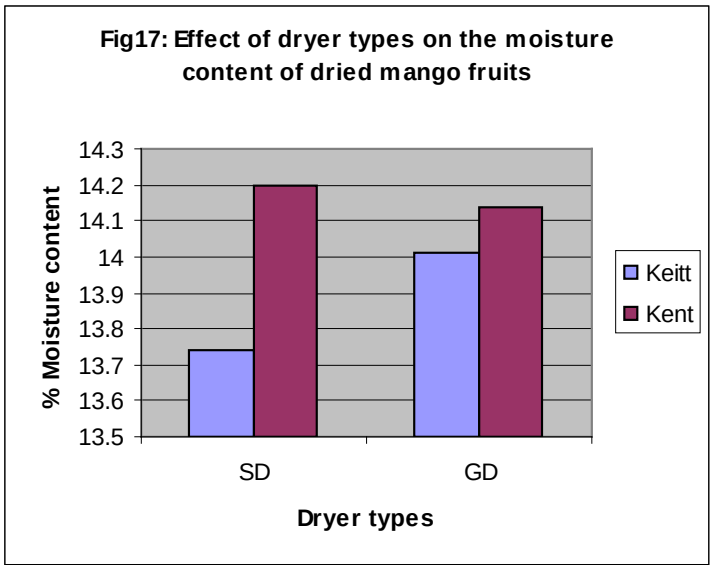


Fig17: Effect of dryer types on the moisture content of dried mango fruits
% Moisture content
14.3
14.2
14.1
14
13.9
13.8
13.7
13.6
13.5
SD
GD
Dryer types
Keitt
Kent

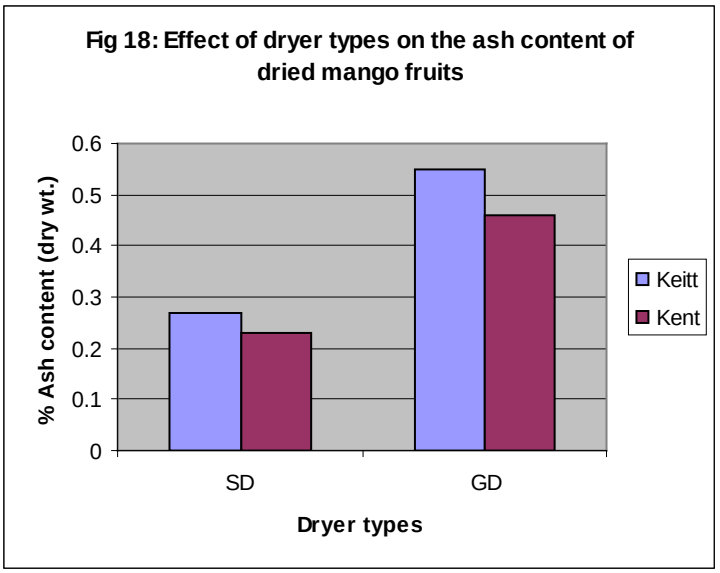


Fig 18: Effect of dryer types on the ash content of dried mango fruits
% Ash content (dry wt.)
0.6
0.5
0.4
0.3
0.2
0.1
0
SD
GD
Dryer types
Keitt
Kent

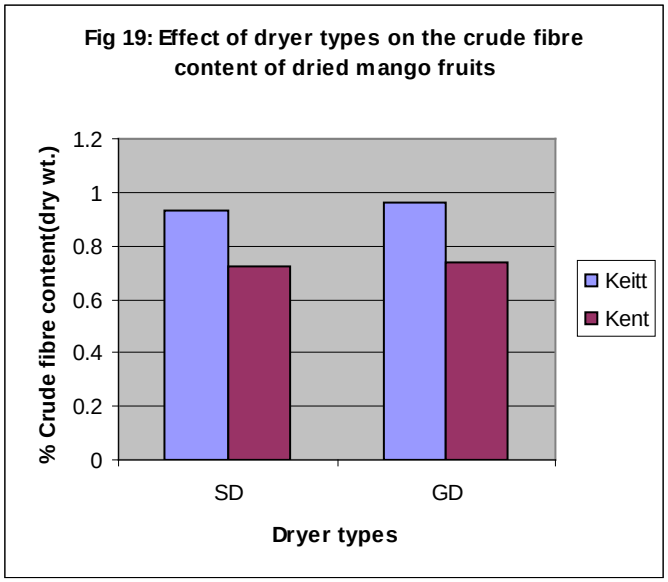


Fig 19: Effect of dryer types on the crude fibre content of dried mango fruits
% Crude fibre content(dry wt.)
1.2
1
0.8
0.6
0.4
0.2
0
SD
GD
Dryer types
Keitt
Kent

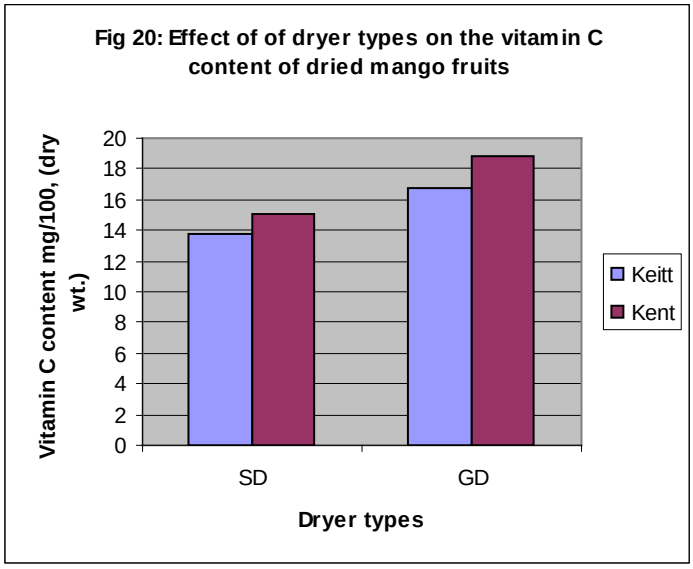


Fig 20: Effect of of dryer types on the vitamin C content of dried mango fruits
Vitamin C content mg/100, (dry wt.)
20
18
16
14
12
10
8
6
4
2
0
SD
GD
Dryer types
Keitt
Kent

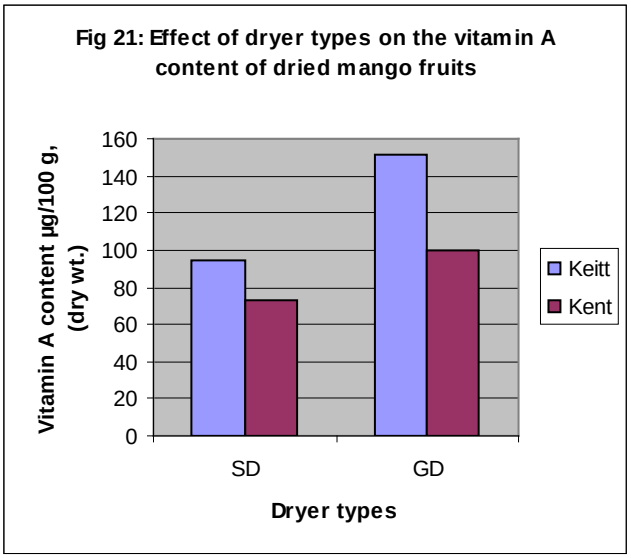


Fig 21: Effect of dryer types on the vitamin A content of dried mango fruits
Vitamin A content µg/100 g, (dry wt.)
160
140
120
100
80
60
40
20
0
SD
GD
Dryer types
Keitt
Kent

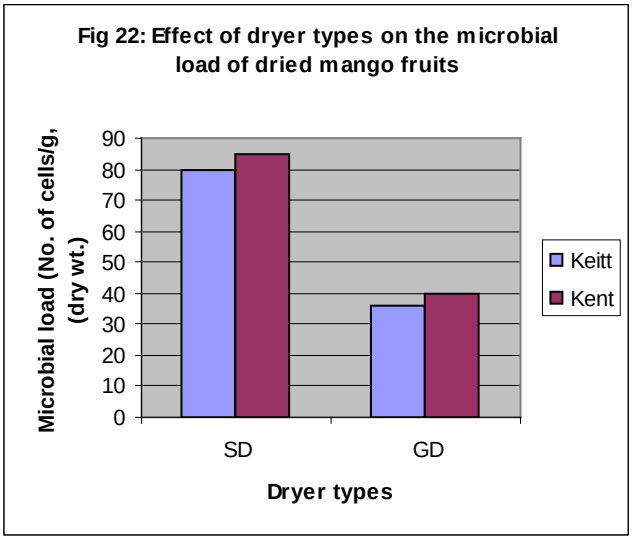


Fig 22: Effect of dryer types on the microbial load of dried mango fruits
Microbial load (No. of cells/g, (dry wt.)
90
80
70
60
50
40
30
20
10
0
SD
GD
Dryer types
Keitt
Kent

4.6 Sensory Evaluation of Pre-treated Solar Dried Mango Fruit

Sensory evaluation was carried out on the pre-treated solar dried mango for colour, taste, aroma, appearance and overall acceptability. The nine point hedonic scale was used for the 50 panellists. The responses of the panellists were tested statistically using Kruskal-Wallis Test to determine if significant differences exist between the various pre-treatments. Lower average ranks indicate better results as compared to higher average ranks.

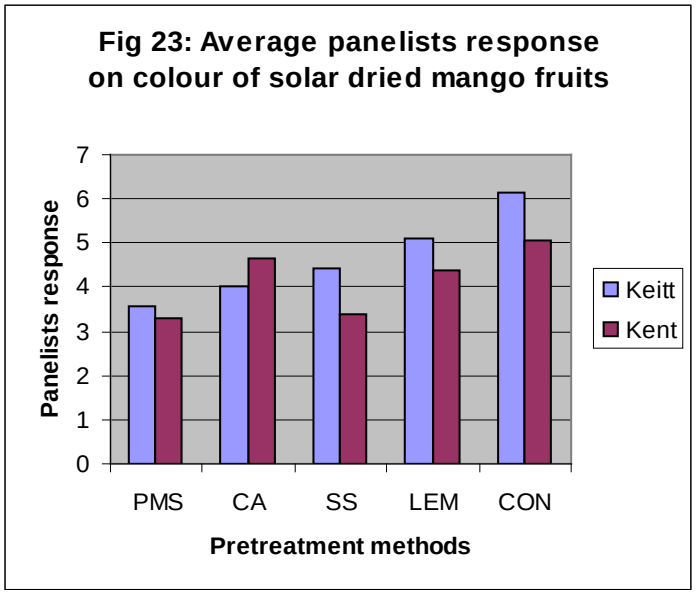
The response of the panellists on colour showed that pre-treatment had significant effect ($p<0.05$) on the colour of the solar cabinet dried mango products (Appendix 2D). The results showed that the panellists preference for the pre-treated products followed a trend of PMS>SS>CA>LEM>CON. Potassium metabisulphite was able to reduce colour loss best in both types of mango varieties followed by SS in that order (Figure 23, Appendix H Table 12). The potassium metabisulphite pre-treated sample was more preferred with respect to fruit colour than the others. The control sample was the least preferred with respect to fruit colour because the samples had undergone some browning and looking unattractive (Appendix I). There was a significant difference ($p<0.05$) with respect to the colour of the two varieties. This was as a result of their attractive yellow colour due to the natural pigments which were converted to a brown colour (Appendix 2D).

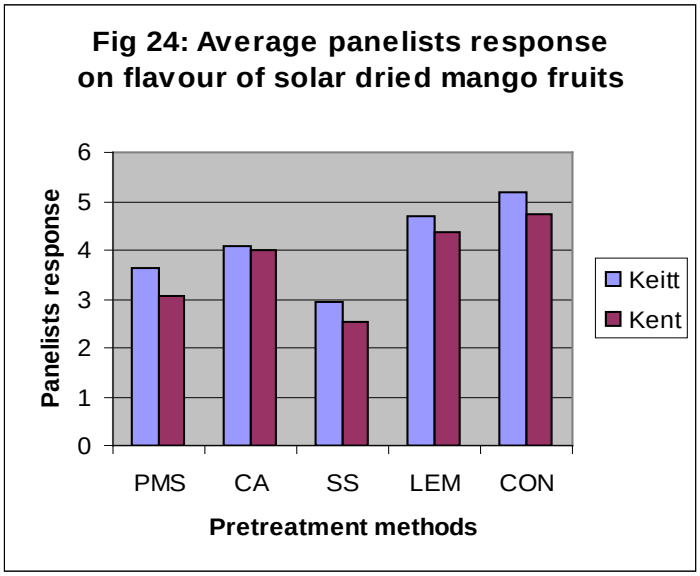
On flavour, panellists response showed that the effect of pre-treatment was significant ($p<0.05$) on the dried product (Appendix 2D). However, sugar syrup pre-treated samples had high preference with respect to flavour. The preference with regards to flavour was in the order of SS>PMS>CA>LEM>CON (Figure 24, Appendix H Table12). The response on flavour showed no significant effect ($p>0.05$) between the two mango types (Appendix 2D).

Pre-treatment had significant effect ($p<0.05$) on the texture of the dried products (Appendix 2D). Potassium metabisulphite treated samples were preferred most than the others with respect to the texture of the dried products. The order of preference for the texture was (PMS>CA>SS>LEM>CON (Figure 25, Appendix H Table12). However, there was no significant difference ($p>0.05$) with regards to the texture of the two varieties (Appendix 2D).

The overall acceptability for the pre-treated samples showed that the various pre-treatment types had significant effect on the acceptability of the solar cabinet dried mango fruits (Appendix 2D). The preference was in the order of PMS>CA>SS LEM>CON (Figure 26, Appendix H Table 12). There were significant differences ($p<0.05$) in the overall acceptability of the two mango types.

The (PMS) samples for both Keitt and Kent varieties were therefore selected for the packaging studies for solar cabinet dried mango fruits.





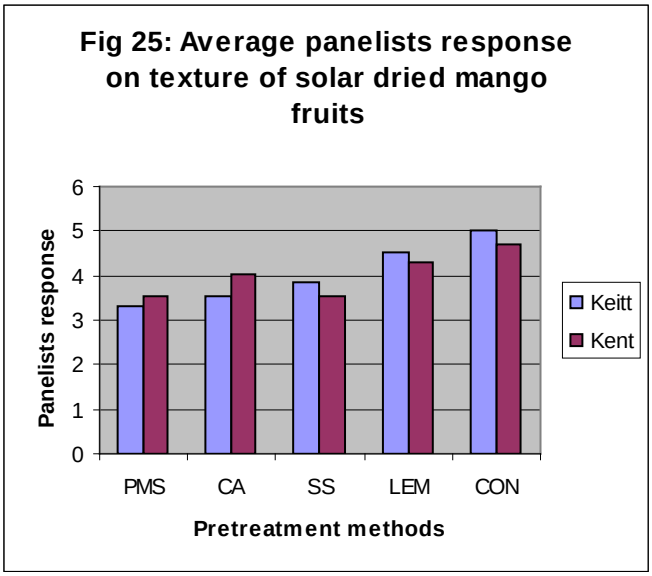


Fig 25: Average panelists response on texture of solar dried mango fruits
Panelists response
0
1
2
3
4
5
6
PMS
CA
SS
LEM
CON
Pretreatment methods
Keitt
Kent

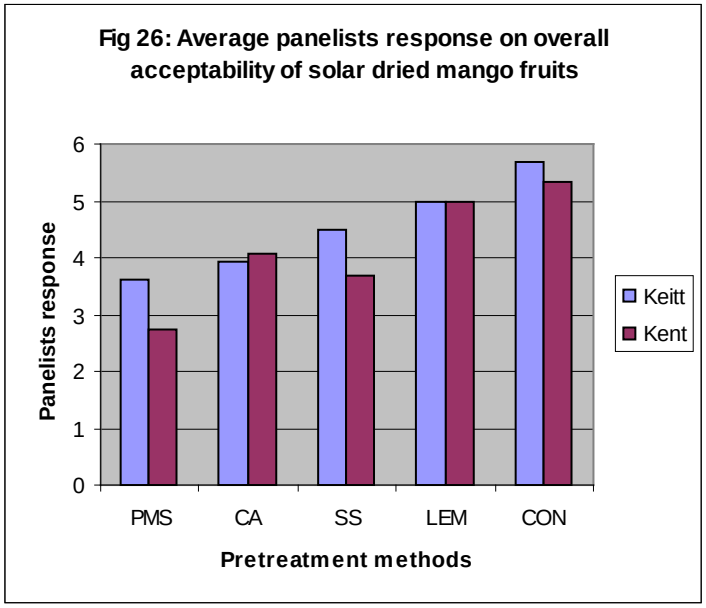


Fig 26: Average panelists response on overall acceptability of solar dried mango fruits
Panelists response
0
1
2
3
4
5
6
PMS
CA
SS
LEM
CON
Pretreatment methods
Keitt
Kent

4.7 Sensory Evaluation of Dried Mango Fruits Using the Solar and Gas Cabinet Dryers

Sensory evaluation was carried out on the untreated solar and gas dried mango products for colour, flavour, texture and overall acceptability using the nine point hedonic scale. A total of 50 panellists were used and the result obtained was analysed statistically using Kruskal- Wallis Test to determine significant differences between the drying methods. The results are presented in (Appendix H Table 13 and Figures 27-30). For all sensory attributes investigated the gas cabinet dryer gave the best results.

The response of panellists on colour indicated that the gas dried mango products for both varieties had significant differences ($p<0.05$) on the colour of the gas dried mango products (Appendix 2E). There was no significant difference ($p>0.05$) on colour between the two varieties for each of the drying methods. The gas dried mango samples looked brighter and retained much of the natural colour than the solar dried mango samples since the solar dried samples had undergone some browning, (Appendix I).

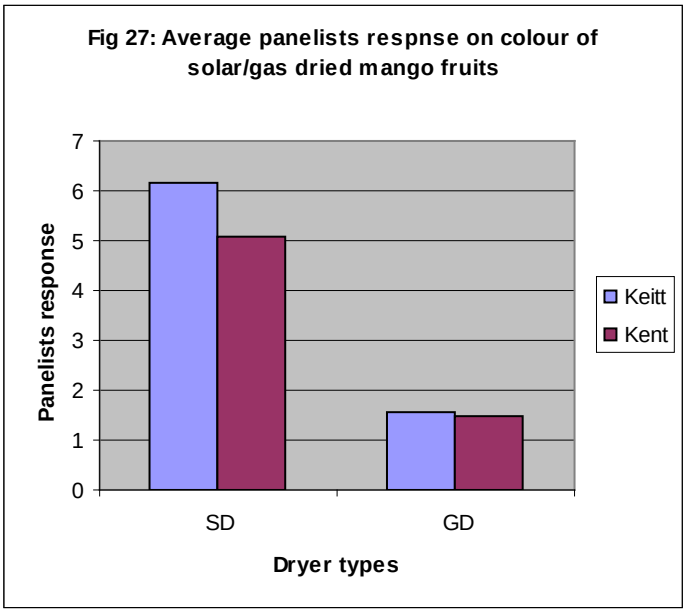
The differences in the colour of the two mango varieties of the two drying methods were basically due to differences in the processing methods. The faster drying conditions observed with regards to the gas cabinet dryer contributed in reducing the incidence of enzymatic browning. However, as a result of the longer drying period observed in the solar dryer, they were prone to enzymatic browning.

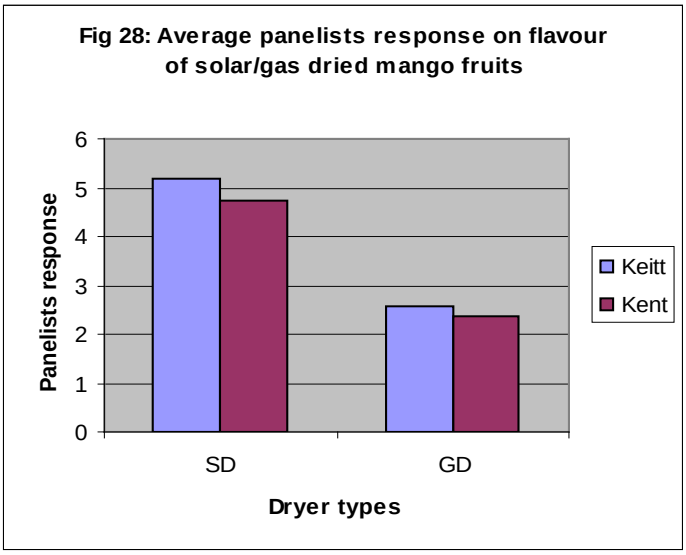
The panellists response on flavour showed that there were significant differences ($p<0.05$) between the varieties using the two drying methods. There were no significant differences ($p>0.05$) between varieties using the different drying methods.

For texture, panellists response shows that there were significant differences ($p<0.05$) between the two mango varieties using the two drying methods. No significant differences in texture ($p>0.05$) were recorded between varieties for each of the two drying methods.

The overall acceptability responses showed that there were significant differences ($p<0.05$) between the dried mango varieties for the two drying methods. Samples of mango fruit slices for both the Keitt and Kent varieties dried in the gas cabinet dryer had better overall acceptance as compared to the samples dried in the solar cabinet dryer. Hence samples dried in the gas cabinet dryer were therefore selected for the packaging studies for Keitt and Kent varieties.

Pictures of the mango fruit slices dried in the solar and gas cabinet dryers are shown in Appendix I.





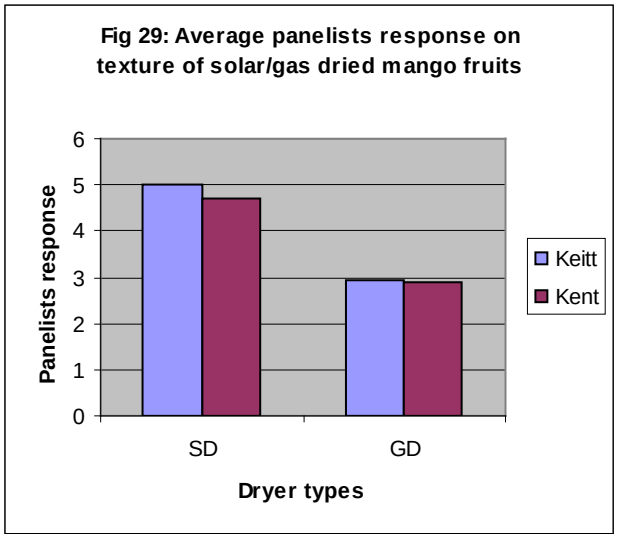


Fig 29: Average panelists response on texture of solar/gas dried mango fruits
Panelists response
0
1
2
3
4
5
6
SD
GD
Dryer types
Keitt
Kent

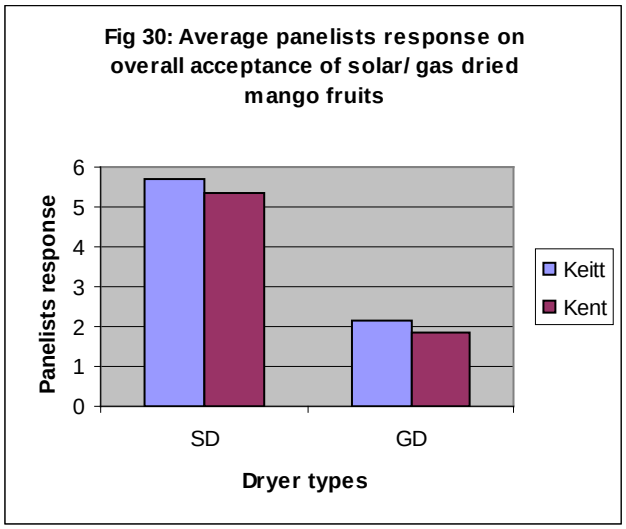


Fig 30: Average panelists response on overall acceptance of solar/ gas dried mango fruits
Panelists response
0
1
2
3
4
5
6
SD
GD
Dryer types
Keitt
Kent

4.8 Effect of Packaging Types and Storage Time on the Quality of Pre-treated Solar Dried Mango Fruit

The results of the effect of packaging material and storage time on the sulphite pre-treated solar dried mango products are shown in (Appendix H Table 14 and Figure 31-33). The results of the moisture content showed a general increase in moisture content with increasing storage time. The moisture content was significantly different ($p<0.05$) with increasing time and package type (Appendix 2F). The results of the moisture content shows that there were significant differences ($p< 0.05$) in the amount of moisture loss in the first month of storage for the two mango varieties, however, there was no significant loss in moisture for the period of the second, third and the fourth months of storage life of the dried mango fruit samples.

There was also a significant ($p<0.05$) effect of package type on moisture content. The high moisture content observed with P2 the control (low density polyethylene bags (LDPE) was due to the fact that LDPE bags have high permeability to oxygen and water vapour diffusion as compared to high density polyethylene bags (HDPE, P1) and polypropylene bags (P3). The increase in moisture with storage time could be attributed to the fact that the dried products picked up moisture from its surroundings (Dennis, 1993). There was no significant differences ($p>0.05$) in moisture increase for P1 and P3 package material for the two varieties. Deterioration and chemical reactions could be higher in P1 with increasing storage time (Dennis, 1993).

Storage time and package type significantly ($p<0.05$) affected the microbial load of the dried mango samples during storage. The increase in the microbial load during storage could be attributed to the water activity as the samples picked up moisture. Salunkhe *et al.,* (1991) reported the effect of water activity on the microbial load of dried foods. The differences in microbial load could be attributed to several factors including moisture absorption, permeability of the package to oxygen and water vapour among others (Dennis, 1993). The P2 package samples recorded a higher microbial load as compared to the P1 and P3 package materials due to high moisture content. There were no significant differences ($p>0.05$) in the microbial load of P1 and P3 package material.

Package material and storage time had significant effect ($p<0.05$) on the vitamin C content during storage. Reduction in the vitamin C and pro-vitamin A content was significant in the P2 samples for both vitamin C and pro-vitamin A during the storage period. This could be attributed to the fact that, increasing moisture content increases water activity a condition suitable for oxidative degradation of vitamins C and pro-vitamin A (Meza *et al.,* 1995; Salunkhe, *et al.,* 1991). There were no significant differences ($p>0.05$) in the losses observed in the P1 and P3 samples with storage time.

Package material and storage time also had a significant effect ($p<0.05$) on both vitamins C and pro-vitamin A content of the dried mango samples. Both P1 and P3 package types recorded better retention of both vitamins C and pro-vitamin A as compared to P2 package material. The P2 pack was more permeable to oxygen and water vapour. The presence of oxygen could also initiate the conversion of vitamins C to dehydroascorbic acid and other oxidised products. Alzamora *et al.,* (2000) reported that light has a significant effect on the stability of vitamin C during storage. This could also be a contributory factor for the loss in both vitamins C and pro-vitamin A in the three package types. The result also showed that there were significant differences ($p<0.05$) in both vitamin C and pro-vitamin A contents with respect to storage time for the two varieties. The differences in the pro-vitamin A and vitamin C content between the varieties with respect to storage time were due to varietal differences.

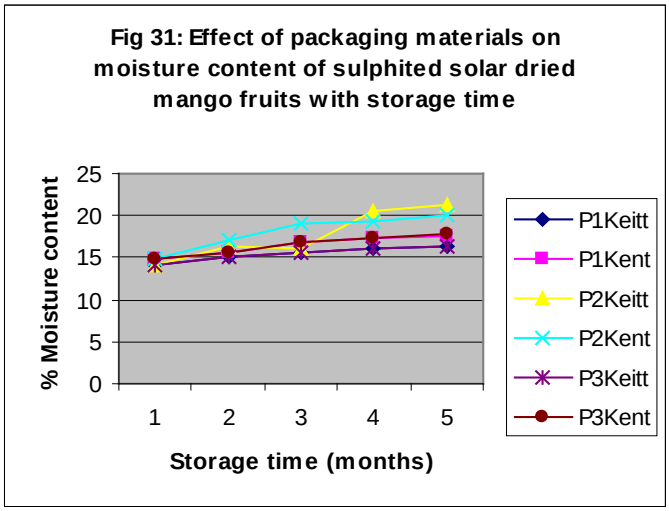


Fig 31: Effect of packaging materials on moisture content of sulphited solar dried mango fruits with storage time
% Moisture content
25
20
15
10
5
0
1
2
3
4
5
Storage time (months)
P1Keitt
P1Kent
P2Keitt
P2Kent
P3Keitt
P3Kent

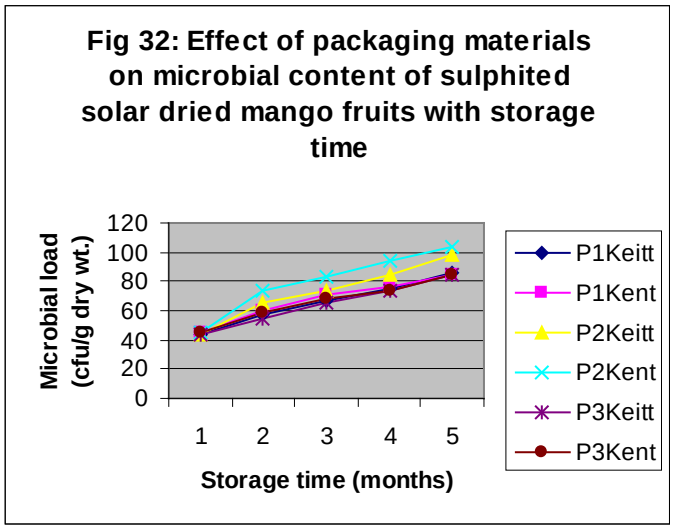
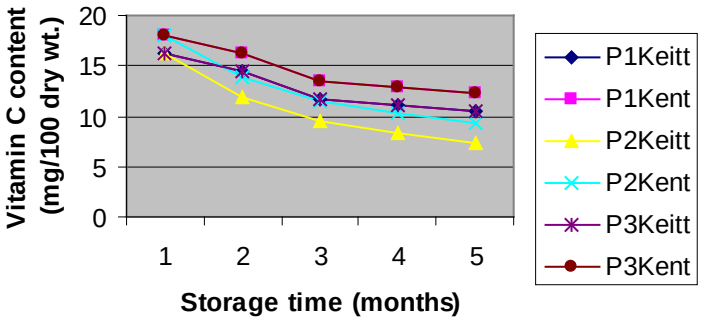


Fig 32: Effect of packaging materials on microbial content of sulphited solar dried mango fruits with storage time
Microbial load (cfu/g dry wt.)
120
100
80
60
40
20
0
1
2
3
4
5
Storage time (months)
P1Keitt
P1Kent
P2Keitt
P2Kent
P3Keitt
P3Kent

Fig 33: Effect of packaging materials on vitamin C content of sulphited solar dried mango fruits with storage time



4.9 Effect of Packaging Types and Storage Time on the Quality of Gas Cabinet Dried Mango Fruits

The results of the effect of packaging material and storage time on the gas cabinet dried mango products are shown in (Appendix H Table 15, Figure 34-36). The results of the moisture content showed a general increase in moisture content with increasing storage time. The moisture content was significantly different ($p<0.05$) with increasing time and package type (Appendix 2G). The results of the moisture content shows that there were significant differences ($p< 0.05$) in the amount of moisture increase in the first month of storage for the two mango varieties, however, there was no significant increase in moisture for the period of the second, third and the fourth months of storage period of the dried mango fruit samples.

There was a significant ($p<0.05$) effect of package type on moisture content. The high increase in moisture content observed with P2 the control (low density polyethylene bags (LDPE) was due to the fact that LDPE bags have high permeability to oxygen and water vapour diffusion as compared to high density polyethylene bags (HDPE, P1) and polypropylene bags (P3). The increase in moisture with storage time could be attributed to the fact that the dried products picked up moisture from its surroundings (Dennis, 1993). There was no significant difference ($p>0.05$) in moisture increase for P1 and P3 package material for the two varieties. Deterioration and chemical reactions could be higher in P2 samples with increasing storage time (Dennis, 1993).

Storage time and package type significantly ($p<0.05$) affected the microbial load of the dried mango samples during storage. The increase in the microbial load during storage could be attributed to the water activity as the samples might have picked up water. Salunkhe *et al.,* 1991 reported on the effect of water activity on the microbial load of dried foods. The differences in microbial load could be attributed to several factors including moisture absorption, permeability of the package to oxygen and water vapour among others (Dennis, 1993). The P2 package material recorded a higher microbial load as compared to the P1 and P3 package materials likely due to its high water activity. There was no significant differences ($p>0.05$) in the microbial load of samples packaged in P1 and P3 package material, (Appendix 2G).

Package material and storage time had a significant effect ($p<0.05$) on the vitamin C content during storage. Reduction in the vitamin C content was significant in the P2 samples for both vitamin C and pro-vitamin A during the storage period. This could be attributed to increasing moisture content which increases water activity a condition suitable for oxidative degradation of vitamin C and pro-vitamin A (Meza *et al.,* 1995; Salunkhe, *et al.,* 1991). There were no significant differences in the losses observed in the P1 and P3 samples with storage time.

Package material and storage time also had a significant effect ($p<0.05$) on both vitamins C and pro-vitamin A content of the dried mango samples. Both P1 and P3 package type's recorded better retention of both vitamins C and pro-vitamin A as compared to P2 package material. The P2 pack was more permeable to oxygen and water vapour. The presence of oxygen could also initiate the conversion of vitamin C to dehydroascorbic acid and other oxidised products. Alzamora *et al.,* (2000) reported that light has a significant effect on the stability of vitamin C during storage. This could also be a contributory factor for the loss in both vitamins C and pro-vitamin A in the three package types.

The results showed that there were significant differences ($p<0.05$) in both vitamins C and pro-vitamin A contents with respect to storage time for the two varieties. Differences were basically due to varietal differences, (Appendix 2G).

Fig 34: Effect of packaging materials on moisture content of gas dried mango fruits with storage time

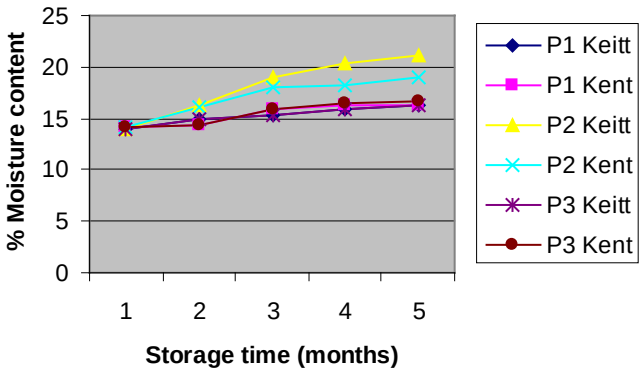


Fig 35: Effect of packaging materials on microbial content of gas dried mango fruits with storage time

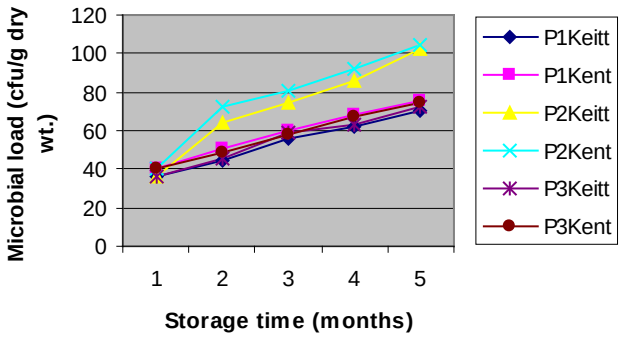
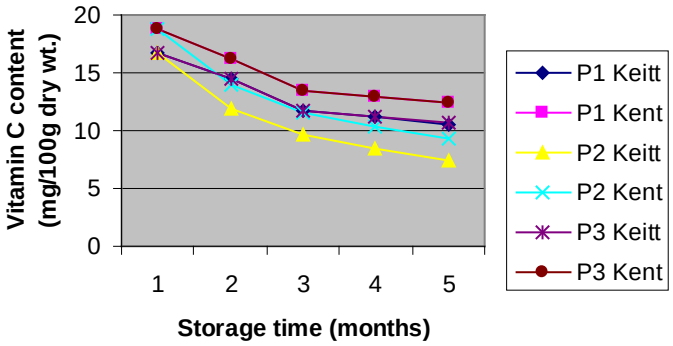


Fig 36: Effect of packaging materials on vitamin C content of gas dried mango fruits with storage time



CHAPTER FIVE

5.0 CONCLUSION

The results showed that sliced mango fruits pre-treated with sulphite and dried at temperature range of 30-55 °C in an improved solar drier for 96 hours (4 days) using fruit slices of 10 mm produced dried mango products of good nutritional and sensory qualities for the two mango cultivars used for the studies. Sliced mango fruit samples of both cultivars which were not subjected to any pre-treatment conditions and dried in a newly designed LPG gas cabinet dryer at temperature range of 52-54 °C for 15 hours using fruit slices of 10 mm also produced dried mango products of good nutritional and sensory qualities. The samples dried in the gas cabinet dryer gave better product as compared to the improved solar dryer.

The results showed packaging dried mango fruits in both high density polyethylene and polypropylene bags were better materials for storing both the solar dried sulphited and the non-sulphited gas cabinet dried mango fruits as compared to the low density polyethylene bags packaging materials as these packaging materials formed good moisture barrier and retained much of their nutrients as compared to the low density polyethylene packaging materials.

Dried mango fruit slices packaged in the high density polyethylene and polypropylene bags had lower microbial load compared to the low density polyethylene bags for both sulphited solar and gas cabinet dried mango fruits samples. High density polyethylene pack (P1) and polypropylene pack (P3) packaging materials were the best packaging material with respect to pro-vitamins A and vitamin C retention of the dried mango fruits samples with storage time.

RECOMMENDATIONS

Based on the outcome of this study and some of the interesting findings, the following would be recommended for adoption by relevant agencies;

1. It is being suggested that as a measure of correcting the vitamin A deficiency among children, the dried mango fruits should be fed to children in the school feeding programme.
2. It is also proposed that as a way of promoting the consumption of the dried mango fruits among the Ghanaian populace, regular food bazaar on the dried mango fruits should be organized by the appropriate agencies to encourage their consumption.
3. It is also recommended that, dried mango fruits should be included in weaning diets as a vitamin A fortifier to correct the deficiency of the mineral among children.
4. The efficiency of the gas cabinet dryer has also being tested to be very effective, and it is therefore recommended for its adoption by farmers for processing of dry fruits.

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APPENDIX 1A

DEPARTMENT OF BIOCHEMISTRY
(FOOD SCIENCE AND TECHNOLOGY)
SENSORY EVALUATION FORM

SEX…….. **DATE……..**

PRODUCT: SOLAR DRIED PRE-TREATED MANGO PRODUCTS (KEITT)

Please, you are provided with various solar dried pre-treated mango products. You are requested to make an independent and fair judgment on the following attributes given below for each coded products.
Using the nine point hedonic scale with number 1, 2, 3 ... (as shown below), please indicate your preference by marching each attribute with an appropriate score or number.

A NINE POINT HEDONIC SCALE

1- Like extremely
2- Like very much
3- Like moderately
4- Like slightly
5- Neither like nor dislike
6- Dislike slightly
7- Dislike moderately
8- Dislike very much
9- Dislike extremely

CODE	APPEARANCE (COLOUR)	FLAVOUR (TASTE & AROMA)	TEXTURE (BY FIRST BITE, CHEWNESS, HARDNESS)	OVERALL ACCEPTANCE
T_1	.....	.....	.....	.....
T2	.....	.....	.....	.....
T3	.....	.....	.....	.....
T 4	.....	.....	.....	.....
T5	.....	.....	.....	.....

KEY T-KEITT

Thank you for your co-operation.

APPENDIX 1B

DEPARTMENT OF BIOCHEMISTRY
(FOOD SCIENCE AND TECHNOLOGY)
SENSORY EVALUATION FORM

SEX…….. **DATE……..**

PRODUCT: SOLAR DRIED PRE-TREATED MANGO PRODUCTS (KENT)

Please, you are provided with various solar dried pre-treated mango products.. You are requested to make an independent and fair judgment on the following attributes given below for each coded products.
Using the nine point hedonic scale with number 1, 2, 3 ... (as shown below), please indicate your preference by marching each attribute with an appropriate score or number.

A NINE POINT HEDONIC SCALE

1- Like extremely
2- Like very much
3- Like moderately
4- Like slightly
5- Neither like nor dislike
6- Dislike slightly
7- Dislike moderately
8- Dislike very much
9- Dislike extremely

CODE	APPEARANCE (COLOUR)	FLAVOUR (TASTE & AROMA)	TEXTURE (BY FIRST BITE, CHEWNESS, HARDNESS)	OVERALL ACCEPTANCE
K_1	……	……	……	……
K2	……	……	……	……
K3	……	……	……	……
K4	……	……	……	……
K5	……	……	……	……

KEY K-KENT

Thank you for your co-operation.

APPENDIX 1C

DEPARTMENT OF BIOCHEMISTRY
(FOOD SCIENCE AND TECHNOLOGY)
SENSORY EVALUATION FORM

SEX…….. **DATE……..**

PRODUCT: SOLAR AND GAS DRIED MANGO PRODUCTS (KEITT AND KENT)

Please, you are provided with various solar and gas dried mango products. You are requested to make an independent and fair judgment on the following attributes given below for each coded products.
Using the nine point hedonic scale with number 1, 2, 3 ... (as shown below), please indicate your preference by marching each attribute with an appropriate score or number.

A NINE POINT HEDONIC SCALE

5- Like extremely
6- Like very much
7- Like moderately
8- Like slightly

5- Neither like nor dislike
6- Dislike slightly
7- Dislike moderately
8- Dislike very much
9- Dislike extremely

CODE	APPEARANCE (COLOUR)	FLAVOUR (TASTE & AROMA)	TEXTURE (BY FIRST BITE, CHEWNESS, HARDNESS)	OVERALL ACCEPTANCE
TSD	……	……	……	……
KGD	……	……	……	……
TSD	……	……	……	……
KGD	……	……	……	……

KEY: T-KEITT, K-KENT
SD- SOLAR DRIED
GD- GAS DRIED

Thank you for your co-operation.

APPENDIX 2A

Analyses of Variance for the Result of the Compositional Differences between Keitt and Kent Mango

Varieties Used for the Study

ANOVA

Moisture

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.764	1	3.764	9.982	.087*****
Within Groups	.754	2	.377		
Total	4.518	3			

*** Not significant**

ANOVA

Ash

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.014	1	.014	72.000	.014******
Within Groups	.000	2	.000		
Total	.015	3			

**** Significant**

ANOVA

Fat

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.001	1	.001	4.500	.168*****
Within Groups	.000	2	.000		
Total	.001	3			

*** Not significant**

ANOVA

Protein

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.051	1	.051	155.769	.006******
Within Groups	.001	2	.000		
Total	.051	3			

**** Significant**

Fibre

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.090	1	.090	450.000	.002**
Within Groups	.000	2	.000		
Total	.090	3			

**** Significant**

ANOVA

Energy

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	87.142	1	87.142	17.391	.053*
Within Groups	10.021	2	5.011		
Total	97.163	3			

*** Not significant**

ANOVA

Vitamin A

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2742.617	1	2742.617	13713084.500	.000**
Within Groups	.000	2	.000		
Total	2742.617	3			

**** Significant**

ANOVA

Vitamin C

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.842	1	3.842	23.482	.040**
Within Groups	.327	2	.164		
Total	4.169	3			

**** Significant**

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	1.000	.423*****
Within Groups	.000	2	.000		
Total	.000	3			

*** Not significant**

ANOVA

Soluble sugars

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.	.
Within Groups	.000	2	.000		
Total	.000	3			

*** Not significant**

ANOVA

Calcium

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.076	1	6.076	386.405	.003******
Within Groups	.031	2	.016		
Total	6.108	3			

**** Significant**

ANOVA

Potassium

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.640	1	17.640	39200.000	.000******
Within Groups	.001	2	.000		
Total	17.641	3			

**** Significant**

ANOVA

Magnesium

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.038	1	.038	117.000	.008**
Within Groups	.001	2	.000		
Total	.039	3			

**** Significant**

ANOVA

Iron

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.012	1	.012	60.500	.016**
Within Groups	.000	2	.000		
Total	.013	3			

**** Significant**

ANOVA

Carbohydrate

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.666	1	4.666	40.908	.024**
Within Groups	.228	2	.114		
Total	4.894	3			

**** Significant**

APPENDIX 2B

Analysis of Variance for the Results of the Effect of Pre-treatment Types on the Quality of Solar Dried Mango Fruits

PMS – 1 CA – 2 SS – 3 LEM – 4 CON – 5

Analysis of Variance for MOISTURE - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	1.87272	1	1.87272	21.96	0.0003*
B:TRT	11.9373	4	2.98433	35.00	0.0000*
RESIDUAL	1.19363	14	0.0852593		
TOTAL (CORRECTED)	15.0037	19			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for MOISTURE by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	10	14.418	0.092336	X
2	10	15.03	0.092336	X

Multiple Range Tests for MOISTURE by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	13.97	0.145996	X
1	4	14.16	0.145996	X
2	4	14.39	0.145996	X
4	4	14.9925	0.145996	X
3	4	16.1075	0.145996	X

Analysis of Variance for ASH - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	0.021125	1	0.021125	36.51	0.0000*
B:TRT	0.10067	4	0.0251675	43.50	0.0000*
RESIDUAL	0.0081	14	0.000578571		
TOTAL (CORRECTED)	0.129895	19			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for ASH by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	10	0.358	0.00760639	X
1	10	0.423	0.00760639	X

Multiple Range Tests for ASH by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	0.28	0.0120268	X
4	4	0.3425	0.0120268	X
3	4	0.41	0.0120268	X
2	4	0.4425	0.0120268	XX
1	4	0.4775	0.0120268	X

Analysis of Variance for FIBER - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	0.194045	1	0.194045	1372.04	0.0000*
B:TRT	0.06523	4	0.0163075	115.31	0.0000*
RESIDUAL	0.00198	14	0.000141429		
TOTAL (CORRECTED)	0.261255	19			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for FIBER by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	10	0.623	0.0037607	X
1	10	0.82	0.0037607	X

Multiple Range Tests for FIBER by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	4	0.655	0.00594619	X
2	4	0.6825	0.00594619	X
3	4	0.715	0.00594619	X
4	4	0.7325	0.00594619	X
5	4	0.8225	0.00594619	X

Analysis of Variance for VIT C - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:TRT	17.2198	4	4.30494	188.34	0.0000*
B:SAMPLE	16.1101	1	16.1101	704.82	0.0000*
RESIDUAL	0.32	14	0.0228571		
TOTAL (CORRECTED)	33.6499	19			

All F-ratios are based on the residual mean square error

* Significant

Multiple Range Tests for C by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	14.3975	0.0755929	X
4	4	16.035	0.0755929	X
3	4	16.2925	0.0755929	X
2	4	16.6875	0.0755929	X
1	4	17.11	0.0755929	X

Multiple Range Tests for C by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	10	15.207	0.0478091	X
2	10	17.002	0.0478091	X

Analysis of Variance for A - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:TRT	3605.69	4	901.421	22.20	0.0000*
B:SAMPLE	9035.5	1	9035.5	222.51	0.0000*
RESIDUAL	568.501	14	40.6072		
TOTAL (CORRECTED)	13209.7	19			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for A by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	83.32	3.18619	X
4	4	106.658	3.18619	X
3	4	115.133	3.18619	XX
2	4	116.775	3.18619	X
1	4	120.81	3.18619	X

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	10	90.895	2.10278	X
1	12	133.405	1.77717	X

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	10	87.284	2.01512	X
1	10	129.794	2.01512	X

Analysis of Variance for MICROBIAL - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:TRT	3774.8	4	943.7	43.01	0.0000*
B:SAMPLE	57.8	1	57.8	2.63	0.1269**
RESIDUAL	307.2	14	21.9429		
TOTAL (CORRECTED)	4139.8	19			

All F-ratios are based on the residual mean square error.

* Significant , ** Not significant

Multiple Range Tests for MICROBIAL by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	4	44.5	2.34216	X
2	4	47.5	2.34216	X
3	4	50.0	2.34216	XX
4	4	55.0	2.34216	X
5	4	82.5	2.34216	X

APPENDIX 2C

Analysis of Variance for the Results of the Effect of Dryer Types on the Nutritional Quality of solar/ Gas Dried Mango Fruits

ANOVA OF GAS VRS SOLAR
SD – 5 GD – 6

Analysis of Variance for MOISTURE - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	0.277513	1	0.277513	35.80	0.0019*
B:TRT	0.0666125	1	0.0666125	8.59	0.0326*
RESIDUAL	0.0387625	5	0.0077525		
TOTAL (CORRECTED)	0.382887	7			

All F-ratios are based on the residual mean square error.
* Significant

Multiple Range Tests for MOISTURE by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	4	13.875	0.0440241	X
2	4	14.2475	0.0440241	X

Multiple Range Tests for MOISTURE by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	13.97	0.0440241	X
6	4	14.1525	0.0440241	X

Analysis of Variance for ASH - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:TRT	0.0968	1	0.0968	302.50	0.0000*
B:SAMPLE	0.02	1	0.02	62.50	0.0005*
RESIDUAL	0.0016	5	0.00032		
TOTAL (CORRECTED)	0.1184	7			

All F-ratios are based on the residual mean square error.
* Significant

Multiple Range Tests for ASH by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	0.28	0.00894427	X
6	4	0.5	0.00894427	X

Multiple Range Tests for ASH by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	4	0.34	0.00894427	X
1	4	0.44	0.00894427	X

Analysis of Variance for FIBER - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	0.726012	1	0.726012	158.09	0.0001*
B:TRT	0.0325125	1	0.0325125	7.08	0.0448*
RESIDUAL	0.0229625	5	0.0045925		
TOTAL (CORRECTED)	0.781488	7			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for FIBER by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	4	0.34	0.033884	X
1	4	0.9425	0.033884	X

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	0.5775	0.033884	X
6	4	0.705	0.033884	X

Analysis of Variance for Vitamin C - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	5.61125	1	5.61125	111.91	0.0001*
B:TRT	23.2562	1	23.2562	463.83	0.0000*
RESIDUAL	0.2507	5	0.05014		
TOTAL (CORRECTED)	29.1182	7			

All F-ratios are based on the residual mean square error.

*** Significant**

Multiple Range Tests for Vitamin C by SAMPLE

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	4	15.265	0.11196	X
2	4	16.94	0.11196	X

Multiple Range Tests for Vitamin C by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	14.3975	0.11196	X
6	4	17.8075	0.11196	X

Analysis of Variance for Vitamin A - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:SAMPLE	2648.46	1	2648.46	30.35	0.0027*
B:TRT	3622.71	1	3622.71	41.52	0.0013*
RESIDUAL	436.307	5	87.2613		
TOTAL (CORRECTED)	6707.48	7			

All F-ratios are based on the residual mean square error.
* Significant

Method: 95.0 percent LSD

SAMPLE	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	4	86.405	4.67069	X
1	4	122.795	4.67069	X

Multiple Range Tests for Vitamin A by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
5	4	83.32	4.67069	X
6	4	125.88	4.67069	X

Analysis of Variance for MICOBIALS - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:TRT	3960.5	1	3960.5	327.31	0.0000*
B:SAMPLE	40.5	1	40.5	3.35	0.1268**
RESIDUAL	60.5	5	12.1		
TOTAL (CORRECTED)	4061.5	7			

All F-ratios are based on the residual mean square error.
* Significant, ** Not significant

Multiple Range Tests for MICOBIALS by TRT

Method: 95.0 percent LSD

TRT	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
6	4	38.0	1.73925	X
5	4	82.5	1.73925	X

APPENDIX 2D

Analysis of Variance for the Results of the Response of Sensory Panellists for Pre-treated Dried Mango fruit

SAMPLES
1- KEITT 2- KENT

TRT
2- PMS 3 –CA 4- SS 5- LEM 6- CON

Kruskal-Wallis Test for COLOUR by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	250	266.562
2	250	234.438

Test statistic = 6.39982 P-Value = 0.0114111*
* Significant

Kruskal-Wallis Test for COLOUR by TRT

TRT	*Sample Size*	*Average Rank*
2	100	176.82
3	100	246.74
4	100	214.465
5	100	269.485
6	100	344.99

Test statistic = 79.5312 P-Value = 0.0*
* Significant

Kruskal-Wallis Test for FLAVOUR by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	250	265.884
2	250	235.116

Test statistic = 5.82809 P-Value = 0.0157698*
* Significant

Kruskal-Wallis Test for FLAVOUR by TRT

TRT	*Sample Size*	*Average Rank*
2	100	210.915
3	100	256.39
4	100	164.105
5	100	298.015
6	100	323.075

Test statistic = 81.7107 P-Value = 0.0*
* Significant

Kruskal-Wallis Test for TEXTURE by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	250	250.108
2	250	250.892

Test statistic = 0.00381056 P-Value = 0.950778**
** Not significant

Kruskal-Wallis Test for TEXTURE by TRT

TRT	*Sample Size*	*Average Rank*
2	100	196.7
3	100	233.045
4	100	225.305
5	100	285.855
6	100	311.595

Test statistic = 43.7262 P-Value = 7.31317E-9**
** Not significant

Kruskal-Wallis Test for OVERALL ACCEPTABILITY by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	250	266.386
2	250	234.614

Test statistic = 6.28626 P-Value = 0.0121656*

* Significant

Kruskal-Wallis Test for OVERALL ACCEPTABILITY by TRT

TRT	*Sample Size*	*Average Rank*
2	100	159.51
3	100	216.31
4	100	218.69
5	100	315.5
6	100	342.49

Test statistic = 115.316 P-Value = 0.0*

* Significant

APPENDIX 2E

Analysis of variance for the Results of the Response of Sensory Panellists for Solar/Gas Dried Mango Fruits

TEST FOR SD -6 AND GD – 1

Kruskal-Wallis Test for COLOUR by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	100	106.565
2	100	94.435

Test statistic = 2.26713 P-Value = 0.132141**

** Not significant

Kruskal-Wallis Test for COLOUR by TRT

TRT	*Sample Size*	*Average Rank*
1	100	55.305
6	100	145.695

Test statistic = 125.891 P-Value = 0.0*

* Significant

Kruskal-Wallis Test for FLAVOUR by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	100	105.92
2	100	95.08

Test statistic = 1.81318 P-Value = 0.178124**

** Not significant

Kruskal-Wallis Test for FLAVOUR by TRT

TRT	*Sample Size*	*Average Rank*
1	100	65.71
6	100	135.29

Test statistic = 74.7054 P-Value = 0.0*

* Significant

Kruskal-Wallis Test for TEXTURE by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	100	102.985
2	100	98.015

Test statistic = 0.378846 P-Value = 0.538221**

* Not significant

Kruskal-Wallis Test for TEXTURE by TRT

TRT	*Sample Size*	*Average Rank*
1	100	71.225
6	100	129.775

Test statistic = 52.5779 P-Value = 0.0*

* Significant

Kruskal-Wallis Test for OVERALL ACCEPTABILITY by SAMPLE

SAMPLE	*Sample Size*	*Average Rank*
1	100	104.035
2	100	96.965

Test statistic = 0.767687 P-Value = 0.380932**

** Not significant

Kruskal-Wallis Test for OVERALL ACCEPTABILITY by TRT

TRT	*Sample Size*	*Average Rank*
1	100	54.86
6	100	146.14

Test statistic = 127.967 P-Value = 0.0*

* Significant

APPENDIX 2F

Analysis of Variance (ANOVA) for the Result of the Effect of Package Type and Storage Time on the Quality of Sulphited Solar Dried Mango Fruit

SOLAR CABINET DRIED

Sample
1: Keitt
2: Kent

Period
1: Month 1
2: Month 2
3: Month 3
4: Month 4

Package
1: P1
2: P2
3: P3

Analysis of Variance for Moisture - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Package	57.6992	2	28.8496	27.26	0.0000
B:Period	31.6495	3	10.5498	9.97	0.0000
C:Sample	8.43363	1	8.43363	7.97	0.0073
RESIDUAL	43.3934	41	1.05838		
TOTAL (CORRECTED)	141.176	47			

All F-ratios are based on the residual mean square error.
* Significant

Multiple Range Tests for Moisture by Package

Method: 95.0 percent LSD

Package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	16	16.3275	0.257194	X
3	16	16.3975	0.257194	X
2	16	18.6875	0.257194	X

Multiple Range Tests for Moisture by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	12	15.8383	0.296981	X
2	12	17.0683	0.296981	X
4	12	17.7558	0.296981	X
3	12	17.8875	0.296981	X

Multiple Range Tests for Moisture by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	24	16.7183	0.209998	X
2	24	17.5567	0.209998	X

Analysis of Variance for Microbial - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Sample	184.083	1	184.083	19.17	0.0001
B:Period	5280.08	3	1760.03	183.29	0.0000
C:Package	2073.38	2	1036.69	107.96	0.0000
RESIDUAL	393.708	41	9.60264		
TOTAL (CORRECTED)	7931.25	47			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for Microbial Load by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	24	73.4167	0.632543	X
2	24	77.3333	0.632543	X

Multiple Range Tests for Microbial Load by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	12	61.3333	1.07071	X
2	12	71.4167	1.07071	X
3	12	78.6667	1.07071	X
4	12	90.0833	1.07071	X

Package

Method: 95.0 percent LSD

Package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
3	16	69.5625	0.774703	X
1	16	72.0	0.774703	X
2	16	84.5625	0.774703	X

Analysis of Variance for Vitamin C - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Package	68.6404	2	34.3202	790.68	0.0000
B:Period	113.783	3	37.9277	873.79	0.0000
C:Sample	40.4985	1	40.4985	933.02	0.0000
RESIDUAL	1.77964	41	0.0434059		
TOTAL (CORRECTED)	224.702	47			

All F-ratios are based on the residual mean square error.

*Signicant

Multiple Range Tests for Vitamin C by Package

Method: 95.0 percent LSD

Package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	16	10.2725	0.0520852	X
1	16	12.7919	0.0520852	X
3	16	12.8263	0.0520852	X

Multiple Range Tests for Vitamin C by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
4	12	10.4117	0.0601428	X
3	12	11.1158	0.0601428	X
2	12	11.845	0.0601428	X
1	12	14.4817	0.0601428	X

Multiple Range Tests for Vitamin C by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	24	11.045	0.0425274	X
2	24	12.8821	0.0425274	X

Analysis of Variance for Vitamin A - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Sample	6520.15	1	6520.15	38.25	0.0000
B:Package	6999.4	2	3499.7	20.53	0.0000
C:Period	124.579	1	124.579	0.73	0.4033
RESIDUAL	3238.92	19	170.469		
TOTAL (CORRECTED)	16883.0	23			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for Vitamin A by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	12	78.28	3.76906	X
1	12	111.245	3.76906	X

Multiple Range Tests for VitaminA by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
4	12	92.4842	3.76906	X
3	12	97.0408	3.76906	X

Multiple Range Tests for Vitamin A by Package

Method: 95.0 percent LSD

Package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	8	70.6113	4.61613	X
1	8	106.831	4.61613	X
3	8	106.845	4.61613	X

APPENDIX 2G

ANOVA- GAS DRIED SAMPLE

Analysis of Variance for moisture - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Sample	0.486019	1	0.486019	0.88	0.3532
B:package	89.143	2	44.5715	80.89	0.0000
C:Period	48.599	3	16.1997	29.40	0.0000
RESIDUAL	22.5928	41	0.551043		
TOTAL (CORRECTED)	160.821	47			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for moisture by package

Method: 95.0 percent LSD

package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
3	16	15.5925	0.185581	X
1	16	15.6881	0.185581	X
2	16	18.53	0.185581	X

Multiple Range Tests for moisture by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	12	14.9975	0.21429	X
2	12	16.5625	0.21429	X
3	12	17.19	0.21429	X
4	12	17.6642	0.21429	X

Analysis of Variance for microbial Load - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:package	6086.29	2	3043.15	129.17	0.0000
B:Period	5040.23	3	1680.08	71.31	0.0000
C:Sample	165.021	1	165.021	7.00	0.0115
RESIDUAL	965.937	41	23.5595		
TOTAL (CORRECTED)	12257.5	47			

All F-ratios are based on the residual mean square error.

* Significant

Multiple Range Tests for microbial Load by package

Method: 95.0 percent LSD

package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
3	16	60.0	1.21345	X
1	16	60.875	1.21345	X
2	16	84.3125	1.21345	X

Multiple Range Tests for microbial Load by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	12	54.3333	1.40117	X
2	12	64.8333	1.40117	X
3	12	72.0	1.40117	X
4	12	82.4167	1.40117	X

Multiple Range Tests for microbial Load by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	24	66.5417	0.990779	X
2	24	70.25	0.990779	X

Analysis of Variance for Vitamin C - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:package	69.2245	2	34.6123	827.10	0.0000
B:Period	113.901	3	37.967	907.26	0.0000
C:Sample	41.2552	1	41.2552	985.84	0.0000
RESIDUAL	1.71576	41	0.0418478		
TOTAL (CORRECTED)	226.096	47			

All F-ratios are based on the residual mean square error.

* Signicant

Multiple Range Tests for Vitamin C by package

Method: 95.0 percent LSD

package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	16	10.3138	0.0511418	X
1	16	12.8575	0.0511418	X
3	16	12.865	0.0511418	X

Multiple Range Tests for Vitamin C by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
4	12	10.455	0.0590535	X
3	12	11.1642	0.0590535	X
2	12	11.9	0.0590535	X
1	12	14.5292	0.0590535	X

Multiple Range Tests for Vitamin C by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
1	24	11.085	0.0417571	X
2	24	12.9392	0.0417571	X

Analysis of Variance for Vitamin A - Type III Sums of Squares

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
A:Period	137.856	1	137.856	719.99	0.0000
B:Sample	15923.8	1	15923.8	83165.77	0.0000
C:package	1076.46	2	538.228	2811.02	0.0000
RESIDUAL	3.63794	19	0.191471		
TOTAL (CORRECTED)	17141.8	23			

All F-ratios are based on the residual mean square error.

*Significant

Multiple Range Tests for Vitamin A by Period

Method: 95.0 percent LSD

Period	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
4	12	104.853	0.126317	X
3	12	109.647	0.126317	X

Multiple Range Tests for Vitamin A by Sample

Method: 95.0 percent LSD

Sample	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	12	81.4917	0.126317	X
1	12	133.008	0.126317	X

Multiple Range Tests for Vitamin A by package

Method: 95.0 percent LSD

package	*Count*	*LS Mean*	*LS Sigma*	*Homogeneous Groups*
2	8	97.7788	0.154706	X
1	8	111.975	0.154706	X
3	8	111.996	0.154706	X

APPENDIX H

Table 7: Results of Moisture changes of Mango Fruits using Solar Dryer

Pretreatment Types	Drying time									
	0 hr		24 hr		48 hr		72 hr		96 hr	
	Keitt	Kent	Keitt	Kent	Keitt	Kent	Keitt	Kent	Keitt	Kent
PMS (%)	80.84	82.78	60.16	61.74	49.20	50.60	29.41	30.18	14.18	14.89
CA (%)	80.84	82.78	61.20	61.80	49.34	51.45	30.24	31.84	13.88	14.27
SS (%)	80.84	82.78	63.14	64.26	52.72	54.78	32.51	33.96	15.90	16.32
LEM (%)	80.84	82.78	62.80	63.90	51.12	52.04	30.92	31.98	14.39	15.63
CON (%)	80.84	82.78	59.25	52.67	47.38	41.08	21.29	22.76	13.74	14.20

KEY: PMS-Potassium metabisulphite pre-treatment, CA-Citric Acid pre-treatment, SS-Sugar blanch pre-treatment, LEM- Lemon juice pre-treatment, CON- Control (samples with no pre-treatment)

TABLE 8: Results of Moisture changes of Keitt/Kent Mango Fruits using Gas Dryer

Variety/drying method	0 hr	2 hr	4 hr	6 hr	8 hr	10 hr	12 hr	14 hr	16 hr
Keitt/gas (%)	80.84	70.63	62.70	53.24	43.46	32.86	22.43	18.26	14.01
Kent/gas (%)	82.78	71.62	63.26	52.76	44.29	33.62	21.41	17.09	14.14

TABLE 9: Results of Moisture changes of Keitt/Kent Mango Fruits using Solar Dryer

Drying time	Variety	
	Keitt (%)	Kent (%)
0 hr	80.84	82.78
2 hr	77.32	77.86
4 hr	73.60	74.92
6 hr	70.14	71.62
8 hr	66.53	67.72
10 hr	62.42	63.82
12 hr	58.12	59.94
14 hr	52.72	53.64
16 hr	48.25	49.81
18 hr	45.26	46.80
20 hr	42.51	43.42
22 hr	39.45	40.38
24 hr	36.80	37.71
48 hr	27.84	28.61
72 hr	20.43	19.36
96 hr	13.74	14.20

Table 10: Results of the Effect of Pre-treatment types on the Quality of the Solar Dried Mango Fruits

Parameter monitored	Mango variety	Pre-treatment Types				
		PMS	CA	SS	LEM	CON
Moisture Content % (dry wt.)	Keitt	14.18 ± 0.21	13.88 ± 0.32	15.90 ±0.15	14.39 ±0.22	13.74 ±0.19
	Kent	14.89 ±1.06	14.27 ±0.92	16.32 ±0.03	15.63 ±0.21	14.20 ±0.17
Ash content (dry wt.)	Keitt	0.51 ±0.06	0.47 ±0.06	0.44 ±0.06	0.37 ±0.06	0.27 ±0.20
	Kent	0.45 ±0.11	0.42 ±0.07	0.38 ±0.09	0.32 ±0.12	0.23 ±0.05
Crude fibre (% dry wt.)	Keitt	0.75 ±0.08	0.78 ±0.06	0.82 ±0.05	0.83 ±0.05	0.93 ±0.06
	Kent	0.57 ±0.05	0.59 ±0.05	0.62 ±0.05	0.64 ±0.05	0.72 ±0.05
Vitamin C content (mg/100g dry wt.)	Keitt	16.14 ±0.09	15.81 ±0.08	15.30 ±0.08	15.06 ±0.15	13.74 ±0.08
	Kent	18.08 ±0.09	17.57 ±0.12	17.29 ±0.06	17.01 ±0.12	15.06 ±0.15
Vitamin A content (µg/100g dry wt.)	Keitt	145.21 ±0.06	141.34 ±0.06	139.84 ±0.00	128.46 ±0.00	94.12 ±0.00
	Kent	96.41 ±0.00	92.21 ±0.06	90.42 ±0.00	84.85 ±0.00	72.51 ±0.06
Microbial load (cfu/g of dry fruit)	Keitt	44 ±2.00	47 ±2.62	50 ±2.00	55 ±2.00	80 ±2.62
	Kent	45 ±2.62	48 ±2.62	50 ±2.62	60 ±3.18	85 ±1.25

KEY: Potassium metabisulphite pre-treatment (PMS), Citric acid pre-treatment (CA), Sugar syrup pre-treatment (SS), Lemon juice pre-treatment (LEM), Control-no pre-treatment (CON), ± -Standard Deviation.

TABLE 11: Comparison of the Effect of Solar Cabinet Dryer and the Gas Cabinet Dryer on the nutritional Composition of Mango Fruits

Parameter Monitored	Mango Variety	Drying Parameter	
		Solar cabinet Dryer	Gas cabinet Dryer
% Moisture Content	Keitt	13.74	14.01
	Kent	14.20	14.14
Ash Content (% dry wt.)	Keitt	0.27	0.55
	Kent	0.23	0.46
Crude Fibre Content (% dry wt.)	Keitt	0.93	0.96
	Kent	0.72	0.74
Vitamin C Content (mg/100 dry wt.)	Keitt	13.74	16.80
	Kent	15.06	18.82
Pro-vitamin A Content (μg/100 dry wt.)	Keitt	94.12	151.46
	Kent	72.51	100.29
Microbial Load (cfu/g of dry wt.)	Keitt	80.00	36.00
	Kent	85.00	40.00

Table 12: Results of the Pre-treated Dried Mango types on the Sensory Qualities of the Solar Died Mango Fruits

Sensory Attribute Monitored	Mango Variety	Pre-treatment Dried Types				
		PMS	CA	SS	LEM	CON
Colour	Keitt	3.58	4.02	4.44	5.10	6.16
	Kent	3.30	4.66	3.40	4.40	5.08
Flavour	Keitt	3.62	4.08	2.92	4.70	5.20
	Kent	3.08	3.98	2.52	4.38	4.74
Texture	Keitt	3.32	3.54	3.86	4.54	5.00
	Kent	3.52	4.02	3.52	4.30	4.70
Overall Acceptability	Keitt	3.60	3.94	4.48	5.00	5.68
	Kent	2.74	4.08	3.70	4.98	5.34

KEY: PMS – Potassium Metabisulphite Pre-treatment, CA – Citric Acid Pre-treatment, SS – Sugar Syrup Pre-treatment, LEM – Lemon Juice Pre-treatment, CON – Control (no pre-treatment).

Table13: Results of the Dryer types on the Sensory Qualities of Dried Mango Fruits

Sensory Attribute Monitored	Mango Variety	Dryer Types	
		Solar cabinet dryer (SD)	Gas cabinet dryer(GD)
Colour	Keitt	6.16	1.56
	Kent	5.08	1.48
Flavour	Keitt	5.20	2.56
	Kent	4.74	2.38
Texture	Keitt	5.00	2.94
	Kent	4.70	2.88
Overall Acceptability	Keitt	5.68	2.16
	Kent	5.34	1.86

Table 14: Results of the Effect of Package Type and Storage Time on the Quality of Sulphite Pre-treated Solar Dried Mango Fruits

Parameter Monitored	Mango Variety	Package Type	Storage Time (Months)				
			0	1	2	3	4
% Moisture Content (dry wt.)	Keitt	P1	14.18	15.12 ±0.02	15.54 ±0.02	16.08 ±0.00	16.44 ±0.00
		P2	14.18	16.37 ±0.06	19.21 ±0.06	20.52 ±0.02	21.30 ±0.02
		P3	14.18	15.07 ±0.00	15.49 ±0.02	16.03 ±0.02	16.38 ±0.00
	Kent	P1	14.89	15.60 ±0.06	16.83 ±0.02	17.37 ±0.00	17.66 ±0.02
		P2	14.89	17.18 ±0.00	19.04 ±0.00	19.34 ±0.02	20.13 ±0.06
		P3	14.89	15.48 ±0.12	16.90 ±0.06	17.44 ±0.02	17.73 ±0.00
Microbial Load (cfu/g)	Keitt	P1	44	57 ±1.26	67 ±1.26	75 ±1.02	86 ±0.00
		P2	44	66 ±0.00	74 ±0.06	84 ±1.26	98 ±1.26
		P3	44	54 ±1.26	66 ±0.90	73 ±0.00	84 ±1.26
	Kent	P1	45	60 ±0.00	71 ±0.06	76 ±0.02	85 ±0.02
		P2	45	74 ±0.02	83 ±0.00	94 ±0.06	104 ±0.00
		P3	45	58 ±1.26	68 ±1.26	73 ±0.06	84 ±0.90

Continuation of Table 14

Parameter Monitored	Mango Variety	Package Type	Storage Time (Months)				
			0	1	2	3	4
Vitamin C (mg/100 g dry wt.)	Keitt	P1	16.14	14.37 ±0.08	11.60 ±0.08	11.11 ±0.02	10.54 ±0.02
		P2	16.14	11.93 ±0.06	9.53 ±0.06	8.33 ±0.02	7.37 ±0.00
		P3	16.14	14.39 ±0.00	11.64 ±0.00	11.15 ±0.06	10.58 ±0.02
	Kent	P1	18.08	16.14 ±0.02	13.39 ±0.08	12.88 ±0.06	12.31 ±0.00
		P2	18.08	13.89 ±0.00	11.47 ±0.02	10.32 ±0.08	9.34 ±0.06
		P3	18.08	16.17 ±0.08	13.44 ±0.08	12.91 ±0.06	12.33 ±0.00
Pro-vitamin A (µg/100 g dry wt.)	Keitt	P1	145.21	-	-	134.62 ±0.00	128.40 ±0.02
		P2	145.21	-	-	72.46 ±0.02	68.92 ±0.02
		P3	145.21	-	-	134.66 ±0.00	128.42 ±0.02
	Kent	P1	96.41	-	-	84.18 ±0.02	80.13 ±0.00
		P2	96.41	-	-	72.14 ±0.00	68.94 ±0.00
		P3	96.41	-	-	84.21 ±0.02	80.10 ±0.02

KEY: Package Type

P1- High density Polyethylene Pack

P2- Low density Polyethylene Pack (Control)

P3- Polypropylene Pack

Table 15: Results of the Effect of Package Types and Storage Time on the Quality of Gas Dried Mango Fruits

Parameter monitored	Mango type	Package type	Storage time (Months)				
			0	1	2	3	4
% Moisture Content	Keitt	P_1	14.01	14.90 ±1.12	15.32 ±0.36	15.86 ±0.36	16.21 ±0.36
		P_2	14.01	16.21 ±0.17	19.06 ±0.15	20.37 ±0.16	21.14 ±0.11
		P_3	14.01	14.93 ±1.27	15.35 ±0.36	15.89 ±0.48	16.24 ±0.36
	Kent	P_1	14.14	14.40 ±0.60	15.82 ±0.51	16.32 ±0.51	16.25 ±0.52
		P_2	14.14	16.13 ±0.90	17.99 ±0.90	18.29 ±0.90	19.08 ±0.90
		P_3	14.14	14.43 ±0.70	15.85 ±0.70	16.39 ±0.70	16.68 ±0.70
Microbial Load (cfu/g)	Keitt	P_1	36	44 ±2.00	56 ±3.00	62 ±3.00	70 ±2.00
		P_2	36	64 ±3.18	75 ±0.00	86 ±2.16.	102 ±2.92
		P_3	36	46 ±2.16	59 ±2.62	63 ±2.00	72 ±0.00
	Kent	P_1	40	51 ±2.62	60 ±2.00	68 ±2.00	76 ±1.26
		P_2	40	72 ±3.17	81 ±1.26	92 1.26±	104 ±2.00
		P_3	40	49 ±2.62	58 ±2.62	67 ±2.62	75 ±2.00

Continuation of Table 15

Parameter monitored	Mango variety	Package type	Storage Time (Months)				
			0	1	2	3	4
Vitamin C Content (mg/100g)	Keitt	P_1	16.80	14.41 ±0.08	11.69 ±0.08	11.15 ±0.08	10.58 ±0.11
		P_2	16.80	11.98 ±0.08	9.58 ±0.08	8.38 ±0.08	7.41 ±0.06
		P_3	16.80	14.42 ±0.00	11.67 ±0.08	11.18 ±0.09	10.61 ±0.08
	Kent	P_1	18.82	16.23 ±0.08	13.48 ±0.06	12.96 ±0.06	12.39 ±0.08
		P_2	18.82	13.93 ±0.06	11.51 ±0.08	10.37 ±0.06	9.38 ±0.08
		P_3	18.82	16.22 ±0.15	13.49 ±0.15	12.96 ±0.15	12.38 ±0.15
Vitamin A Content (µg/100g)	Keitt	P_1	151.46	-	-	140.42 ±0.06	135.22 ±0.06
		P_2	151.46	-	-	126.33 ±0.02	120.36 ±0.00
		P_3	151.46	-	-	140.48 ±0.06	135.24 ±0.06
	Kent	P_1	100.29	-	-	88.22 ±0.00	84.03 ±0.06
		P_2	100.29	-	-	74.17 ±0.00	70.26 ±0.00
		P_3	100.29	-	-	88.26 ±0.06	84.01 ±0.06

APPENDIX I

KENT GAS (UNTREATED)

KEITT GAS (UNTREATED)

KENT SOLAR (PMS)

KEITT SOLAR (PMS)

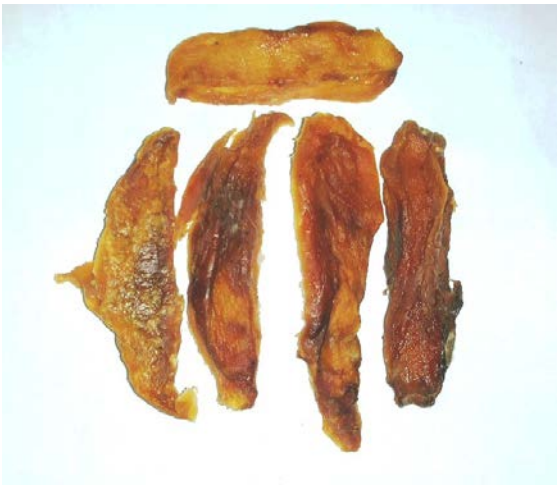
KENT SOLAR (CITRIC ACID)

KEITT SOLAR (CITRIC ACID)

KENT SOLAR (SUGAR)

KEITT SOLAR (SUGAR)

KENT SOLAR (LEMON)



KEITT SOLAR (LEMON)

KENT SOLAR (CONTROL)

KEITT SOLAR (CONTROL)

APPENDIX J

Formulae

1.0 Moisture Content (%) = $\frac{\text{Initial Weight – Final Weight x 100}}{\text{Initial Weight}}$

2.0 Ash Content (%) = $\frac{\text{Final Weight x 100}}{\text{Initial Weight}}$

3.0 Potassium Dioxide Content (Pearson, 1970) =
PO_2 (ppm) = Normality of x Molecular Mass x Volume of x $\frac{1000}{}$

Iodine (0.02N) of iodine (32) iodine used 20

4.0 Converting % Fresh Weight to % Dry Weight

% Dry Weight $= \frac{\text{\% Fresh Weight x 100}}{\text{Dry Matter}}$

Dry Matter = (100 - % Moisture content)

5.0 Microbial load = $\frac{\text{Number of Colonies}}{\text{Dilution Factor}}$

6.0 Dye Standardization for Vitamin C Determination =

$$\frac{1}{1000} \times \frac{mlNa_2S_2O_3 \times Normality\ of\ Na_2S_2O_3 \times 88 \times 1000}{ml\ Dye}$$

7.0 Ascorbic acid per 100 ml juice = Dye equivalent x titer x dilution if 1.05 ml dye were required for titration

8.0 % Total nitrogen $= \frac{(V_A - V_B) \text{ x } N_A \text{ x } 0.01401 \text{ x} 100}{W \text{ x } 10}$

VA - vol. In ml of standard acid used in titration

VB – vol. vol. in ml of standard acid used in blank

NA – normality of acid (HCL)

W - Weight in grams of the sample

Protein = % nitrogen x 6.25

9.0 Crude fibre = Weight of dried sample – Weight of ashed sample

10.0 % Crude fat = $\frac{\text{Weight of flask + Oil – Weight of flask x 100}}{\text{Weight of sample}}$

Results of sensory Analysis for Pre-treated Dried Mango Samples

PANALIST RESPONSE – COLOUR – MANGO (KEITT)

PANELIST	PMS	CA	SS	LEM	CON
1	3	4	6	4	6
2	2	3	4	5	7
3	1	1	1	1	3
4	1	3	4	6	9
5	3	4	4	3	7
6	3	3	4	5	6
7	5	4	3	5	1
8	3	3	5	5	6
9	2	4	5	6	6
10	4	7	4	4	5
11	2	3	2	4	4
12	4	4	3	6	4
13	3	6	2	4	4
14	1	9	6	3	9
15	3	4	7	8	9
16	3	2	3	4	7
17	3	5	3	5	5
18	9	7	8	6	8
19	4	4	3	6	7
20	2	4	5	5	7
21	3	5	5	9	3
22	3	6	7	7	5
23	3	4	5	2	6
24	3	3	3	4	6
25	3	4	4	4	7
26	5	2	2	4	5
27	5	5	5	4	7
28	9	8	9	9	9
29	4	4	4	4	4
30	3	4	4	6	7
31	3	3	4	7	5
32	1	3	3	3	2
33	3	3	2	3	6
34	7	5	5	4	7
35	4	3	4	4	6
36	3	4	4	5	6
37	2	3	5	3	5
38	4	2	2	3	5
39	3	4	6	5	9
40	6	4	9	4	9
41	6	6	3	9	6
42	4	3	4	6	8
43	2	4	3	7	6
44	2	4	3	6	7
45	3	3	4	6	7
46	2	4	3	6	7
47	6	4	3	3	7
48	5	4	5	5	6
49	6	4	6	6	7
50	5	1	4	3	8

PANELIST RESPONSE - FLAVOUR – MANGO (KEITT)

PANELISTS	PMS	CA	SS	LEM	CON
1	3	2	4	1	5
2	2	3	2	5	5
3	1	1	1	2	3
4	2	3	1	7	9
5	3	2	3	3	2
6	2	3	1	3	5
7	4	4	4	4	3
8	5	3	4	4	3
9	6	5	2	7	6
10	2	4	3	4	5
11	4	5	4	3	5
12	4	3	4	4	2
13	3	6	3	3	5
14	5	4	3	2	6
15	2	4	1	3	4
16	1	3	2	8	9
17	2	2	3	3	5
18	3	5	5	5	5
19	4	4	1	3	4
20	3	3	1	5	3
21	4	3	1	4	7
22	2	4	2	2	5
23	4	6	2	7	5
24	4	6	3	5	7
25	4	6	2	5	3
26	3	4	1	5	7
27	6	2	2	6	3
28	6	4	6	8	7
29	9	9	4	4	9
30	7	6	8	7	6
31	3	4	2	2	6
32	2	4	2	5	6
33	4	3	1	4	3
34	2	5	2	5	3
35	6	3	3	5	8
36	3	4	3	2	6
37	3	4	1	5	7
38	3	2	3	3	3
39	2	3	3	3	4
40	4	4	2	6	4
41	4	5	6	4	5
42	2	9	4	6	8
43	6	3	5	4	7
44	4	7	7	7	5
45	2	3	6	3	4
46	3	4	1	5	8
47	3	4	4	6	6
48	6	5	2	9	7
49	6	7	9	8	9
50	3	4	1	5	8

PANELISTS RESPONSE – TEXTURE– MANGO (KEITT)

PANELISTS	PMS	CA	SS	LEM	CON
1	3	4	1	3	4
2	2	4	1	3	4
3	2	2	2	2	4
4	2	7	6	5	9
5	5	2	5	5	4
6	2	4	5	4	6
7	5	5	4	4	2
8	6	5	4	3	2
9	3	2	4	5	6
10	3	2	5	4	4
11	3	2	5	4	4
12	2	6	4	4	5
13	3	3	2	3	4
14	1	3	3	4	3
15	4	4	2	9	2
16	1	1	2	3	4
17	3	5	3	5	5
18	2	3	2	4	5
19	4	4	3	6	8
20	3	3	6	3	6
21	2	1	6	3	4
22	3	5	9	9	5
23	3	7	1	2	4
24	2	3	5	6	8
25	3	2	2	2	2
26	5	3	4	4	3
27	6	5	2	6	3
28	5	4	5	5	5
29	9	2	7	3	2
30	3	7	7	6	7
31	4	4	5	6	7
32	4	4	3	3	4
33	2	5	4	7	4
34	3	3	4	5	6
35	4	7	7	5	7
36	2	1	1	2	5
37	2	2	4	4	6
38	4	1	4	4	4
39	2	3	2	2	3
40	4	1	4	4	4
41	4	4	5	6	7
42	3	4	4	4	7
43	3	7	3	2	8
44	7	4	2	9	4
45	3	3	4	6	6
46	3	4	4	4	8
47	3	2	3	3	4
48	5	7	7	6	5
49	4	3	6	6	7
50	3	2	6	8	7

PANELISTS RESPONSE – OVERALL ACCEPTANCE – MANGO (KEITT)

PANELISTS	PMS	CA	SS	LEM	CON
1	3	4	6	3	6
2	1	4	5	3	4
3	4	4	4	5	9
4	2	7	5	6	9
5	3	2	5	3	2
6	2	3	4	5	6
7	5	4	5	5	2
8	4	3	4	3	4
9	4	2	3	4	6
10	4	3	5	7	6
11	4	4	4	6	7
12	3	4	4	6	7
13	3	3	4	5	3
14	3	3	4	4	3
15	3	5	7	8	9
16	2	2	3	3	5
17	3	5	3	5	5
18	4	4	3	4	5
19	3	3	3	5	8
20	3	3	5	5	6
21	3	2	6	2	4
22	3	4	4	6	5
23	3	7	2	3	3
24	4	4	4	6	5
25	5	4	5	5	6
26	6	3	3	7	4
27	4	5	6	8	6
28	9	7	5	6	7
29	3	5	6	6	5
30	3	4	4	5	6
31	3	4	5	6	6
32	3	4	2	6	4
33	3	4	4	6	6
34	6	4	4	5	6
35	2	4	3	5	7
36	3	4	4	5	6
37	4	5	6	4	5
38	8	5	4	6	8
39	4	3	4	5	6
40	2	3	2	5	4
41	4	4	4	7	9
42	3	4	3	5	7
43	4	2	5	3	6
44	5	6	7	7	6
45	4	4	5	5	6
46	3	4	3	5	7
47	4	6	6	4	8
48	3	4	4	5	6
49	3	4	4	6	6
50	3	2	4	7	8

PANELISTS RESPONSE – COLOUR – MANGO (KENT)

PANELISTS	PMS	CA	SS	LEM	CON
1	3	4	3	6	7
2	1	6	5	6	4
3	2	3	1	3	4
4	2	9	4	4	2
5	2	1	4	5	2
6	4	3	5	3	5
7	1	5	1	2	3
8	4	7	3	4	4
9	4	5	4	6	8
10	2	4	3	4	7
11	6	4	3	4	4
12	3	5	3	3	2
13	3	6	2	4	4
14	3	4	4	4	4
15	2	4	5	6	8
16	2	3	6	3	3
17	5	6	5	4	8
18	4	6	3	6	9
19	3	1	2	3	1
20	4	6	3	3	4
21	5	9	7	6	9
22	4	4	4	6	7
23	2	6	4	3	5
24	4	6	5	5	5
25	4	4	2	4	7
26	6	3	4	4	7
27	4	3	4	3	4
28	9	9	4	8	9
29	3	4	3	4	6
30	2	4	4	5	6
31	2	5	2	4	3
32	3	4	5	4	6
33	3	3	4	4	6
34	4	7	4	3	3
35	2	6	2	3	3
36	3	4	4	3	5
37	3	3	2	1	2
38	2	6	2	4	7
39	3	2	3	4	6
40	4	6	4	4	6
41	3	4	3	4	4
42	4	3	1	4	2
43	2	4	5	3	6
44	4	3	4	5	6
45	2	3	2	3	6
46	4	4	3	4	8
47	3	7	1	3	6
48	3	6	2	4	7
49	3	6	3	3	4
50	5	6	4	5	7

PANELISTS RESPONSE – FLAVOUR – MANGO (KENT)

PANELISTS	PMS	CA	SS	LEM	CON
1	2	4	3	4	3
2	3	6	4	4	5
3	3	3	2	6	7
4	2	4	1	3	2
5	2	2	2	3	2
6	1	2	1	2	3
7	4	3	6	4	4
8	2	3	1	7	8
9	2	4	1	3	7
10	4	4	2	8	2
11	3	4	1	5	5
12	3	6	2	9	5
13	2	1	4	9	7
14	4	5	5	6	8
15	7	4	2	3	7
16	3	4	1	4	3
17	2	5	4	7	7
18	6	5	1	4	2
19	4	4	1	6	9
20	3	4	1	2	8
21	2	3	2	6	3
22	2	2	3	1	2
23	3	4	4	2	4
24	3	6	1	4	8
25	2	4	1	5	6
26	3	4	4	5	6
27	3	2	2	4	3
28	5	4	3	2	6
29	4	4	3	2	3
30	2	8	4	3	3
31	3	2	3	5	4
32	4	2	5	3	4
33	4	6	3	3	4
34	2	4	3	5	4
35	3	4	4	2	5
36	4	2	3	2	2
37	2	9	3	3	2
38	2	2	2	3	3
39	3	2	3	6	9
40	1	4	2	5	2
41	1	4	2	5	2
42	6	5	2	6	4
43	3	4	1	6	2
44	4	4	3	6	8
45	2	3	2	3	4
46	3	4	1	6	9
47	6	6	1	4	3
48	6	7	4	4	5
49	3	5	3	4	4
50	3	2	4	7	9

PANELISTS RESPONSE – TEXTURE – MANGO (KENT)

PANELISTS	PMS	CA	SS	LEM	CON
1	2	2	1	3	1
2	2	4	3	4	3
3	4	6	4	6	5
4	3	3	2	5	6
5	3	3	4	6	3
6	3	3	3	4	3
7	2	3	3	1	4
8	4	6	5	4	3
9	3	4	2	4	7
10	3	4	4	4	5
11	4	2	5	4	4
12	3	4	4	5	6
13	6	4	4	7	6
14	1	2	3	6	4
15	3	5	5	5	6
16	2	6	4	5	3
17	4	4	3	5	4
18	2	5	4	5	6
19	6	3	2	5	4
20	3	4	4	6	7
21	1	3	6	8	4
22	4	3	3	5	6
23	4	3	2	2	5
24	8	4	3	3	3
25	4	6	8	2	8
26	3	4	4	5	7
27	3	5	6	6	7
28	2	3	1	3	2
29	3	3	2	3	4
30	4	4	3	4	3
31	2	4	4	5	6
32	4	4	5	7	5
33	2	7	4	2	4
34	4	5	4	3	5
35	3	5	4	4	2
36	3	4	3	2	3
37	6	6	3	1	3
38	3	9	3	2	6
39	2	1	2	2	4
40	3	4	3	4	4
41	3	1	4	4	5
42	6	3	3	7	6
43	4	2	4	7	3
44	2	6	5	6	7
45	4	4	2	3	6
46	3	4	4	5	8
47	4	6	2	6	4
48	6	6	5	4	5
49	4	4	2	4	5
50	6	4	3	2	8

PANELISTS RESPONSE – OVERALL ACCEPTANCE – MANGO (KENT)

PANELISTS	PMS	CA	SS	LEM	CON
1	2	4	3	7	8
2	3	4	3	5	6
3	6	6	5	8	9
4	2	9	3	3	6
5	2	3	3	4	4
6	3	4	4	2	4
7	2	4	3	4	3
8	3	4	3	3	4
9	4	6	5	3	4
10	2	4	8	5	6
11	4	4	4	6	7
12	2	3	9	9	8
13	2	3	4	5	3
14	3	4	5	3	3
15	3	4	6	8	9
16	2	3	4	5	7
17	4	6	7	4	8
18	4	4	2	3	4
19	3	4	2	3	3
20	2	3	3	4	6
21	2	4	3	7	5
22	6	3	3	6	5
23	6	3	2	5	4
24	4	5	4	5	6
25	4	4	2	4	3
26	6	3	2	4	8
27	4	5	6	6	7
28	3	3	3	8	5
29	3	4	3	6	6
30	2	4	5	6	7
31	2	4	4	6	5
32	3	5	4	5	6
33	3	3	4	7	3
34	4	4	5	5	3
35	2	4	4	5	6
36	2	4	2	3	2
37	2	2	5	6	7
38	3	3	4	6	7
39	4	6	4	4	6
40	2	4	3	4	3
41	3	4	2	5	4
42	6	2	2	4	3
43	4	4	6	7	4
44	2	5	3	4	7
45	3	4	3	4	6
46	4	4	3	7	8
47	2	4	1	3	6
48	5	6	4	4	6
49	3	4	3	4	4
50	3	4	2	7	8

Results of Sensory Analysis for Solar/ Gas Dried Mango Samples

PANELISTS RESPONSE – COLOUR – MANGO (KEITT)

PANELISTS	GD	SD
1	1	6
2	1	7
3	1	3
4	1	9
5	2	7
6	2	6
7	6	1
8	2	6
9	2	6
10	3	5
11	1	4
12	3	4
13	3	4
14	1	9
15	2	9
16	1	7
17	2	5
18	2	8
19	2	7
20	1	7
21	1	3
22	1	5
23	1	6
24	2	6
25	1	7
26	1	5
27	1	7
28	1	9
29	2	4
30	2	7
31	1	5
32	4	2
33	2	6
34	1	7
35	1	6
36	3	6
37	1	5
38	1	5
39	2	9
40	2	9
41	3	6
42	3	8
43	1	6
44	1	7
45	1	7
46	1	7
47	1	7
48	2	6
49	1	7
50	2	8

PANELISTS RESPONSE – FLAVOUR –MANGO (KEITT)

PANELISTS	GD	SD
1	1	5
2	2	5
3	1	3
4	1	9
5	1	2
6	1	5
7	5	3
8	4	3
9	5	6
10	1	5
11	2	5
12	3	2
13	4	5
14	2	6
15	2	4
16	2	9
17	1	5
18	2	5
19	3	4
20	2	3
21	2	7
22	3	5
23	3	5
24	2	7
25	3	3
26	2	7
27	2	3
28	4	7
29	6	9
30	3	6
31	2	6
32	3	6
33	6	3
34	3	3
35	3	8
36	2	6
37	2	7
38	3	3
39	3	4
40	3	4
41	2	5
42	1	8
43	2	7
44	3	5
45	1	4
46	2	8
47	3	6
48	3	7
49	4	9
50	2	8

PANELISTS RESPONSE – TEXTURE – MANGO (MANGO)

PANELISTS	GD	SD
1	2	4
2	3	4
3	1	4
4	1	9
5	2	4
6	3	6
7	5	2
8	6	2
9	1	6
10	7	4
11	6	4
12	3	5
13	2	4
14	3	3
15	3	2
16	2	4
17	2	5
18	4	5
19	2	8
20	3	6
21	3	4
22	4	5
23	6	4
24	2	4
25	4	2
26	2	3
27	6	3
28	4	5
29	1	2
30	3	7
31	3	7
32	6	4
33	4	4
34	2	6
35	1	7
36	2	5
37	3	7
38	1	4
39	4	3
40	1	4
41	4	7
42	2	7
43	2	8
44	4	4
45	4	6
46	2	8
47	1	4
48	3	4
49	3	7
50	1	7

PANELISTS RESPONSE – OVERALL ACCEPTANCE – MANGO (KEITT)

PANALISTS	GD	SD
1	2	6
2	2	4
3	3	9
4	1	9
5	2	2
6	1	6
7	6	2
8	2	4
9	1	6
10	3	6
11	2	7
12	1	3
13	2	3
14	2	3
15	1	9
16	1	5
17	2	5
18	3	5
19	2	8
20	1	6
21	1	4
22	2	5
23	2	6
24	3	5
25	2	6
26	2	4
27	2	6
28	3	7
29	4	5
30	1	6
31	2	6
32	6	4
33	2	6
34	2	6
35	2	7
36	2	6
37	2	5
38	2	8
39	2	6
40	1	4
41	3	9
42	1	7
43	1	6
44	4	6
45	3	6
46	2	7
47	3	8
48	2	6
49	3	6
50	1	8

PANELISTS RESPONSE – COLOUR – MANGO (KENT)

PANELISTS	GD	SD
1	1	7
2	1	4
3	1	4
4	1	2
5	1	2
6	1	5
7	1	3
8	2	4
9	2	8
10	1	7
11	1	4
12	2	2
13	3	4
14	2	4
15	1	8
16	1	3
17	1	8
18	3	9
19	2	1
20	1	4
21	1	9
22	2	7
23	1	5
24	2	5
25	1	7
26	2	7
27	2	4
28	2	9
29	1	6
30	1	6
31	2	3
32	1	6
33	1	6
34	1	3
35	1	3
36	1	5
37	1	2
38	1	7
39	1	6
40	3	6
41	2	4
42	2	2
43	1	6
44	1	6
45	1	6
46	2	8
47	2	6
48	1	7
49	3	4
50	4	7

PANELISTS RESPONSE – FLAVOUR – MANGO (KENT)

PANELISTS	DG	SD
1	2	3
2	3	5
3	2	7
4	4	2
5	3	2
6	1	3
7	3	4
8	2	8
9	1	7
10	3	2
11	2	5
13	4	7
14	2	8
15	1	7
16	1	3
17	3	7
18	3	2
19	2	9
20	2	8
21	3	3
22	3	2
23	2	4
24	2	8
25	1	6
26	2	6
27	3	3
28	2	6
29	4	3
30	2	3
31	4	4
32	1	4
33	4	4
34	2	4
35	2	5
36	3	2
37	1	2
38	2	3
39	1	9
40	2	7
41	3	2
42	3	4
43	3	2
44	2	8
45	1	4
46	2	9
47	3	3
48	4	5
49	4	4
50	1	9

PANELISTS RESPONSE – TEXTURE –MANGO (KENT)

PANELISTS	GD	SD
1	2	1
2	2	3
3	6	5
4	2	6
5	3	3
6	3	3
7	2	4
8	3	3
9	3	7
10	2	5
11	9	4
12	4	6
13	5	6
14	4	4
15	2	6
16	5	3
17	3	4
18	2	6
19	1	4
20	4	7
21	2	4
22	2	6
23	3	5
24	1	3
25	3	8
26	2	7
27	4	7
28	2	2
29	2	4
30	3	3
31	2	6
32	5	5
33	2	4
34	4	5
35	2	2
36	1	3
37	2	3
38	1	6
39	1	4
40	2	4
41	4	5
42	4	6
43	4	3
44	3	7
45	1	6
46	2	8
47	4	4
48	5	5
49	3	6
50	1	6

PANELISTS RESPONSE – OVERALL ACCEPTANCE – MANGO (KENT)

PANELISTS	GD	SD
1	1	8
2	1	6
3	4	9
4	1	6
5	2	4
6	1	4
7	2	3
8	2	4
9	1	4
10	2	6
11	2	7
12	2	8
13	1	3
14	2	3
15	1	9
16	1	7
17	2	8
18	2	4
19	1	3
20	1	6
21	2	5
22	1	5
23	1	4
24	2	6
25	2	3
26	2	8
27	2	7
28	4	5
29	1	6
30	1	7
31	3	5
32	2	6
33	2	3
34	3	3
35	1	6
36	3	2
37	1	7
38	2	7
39	2	6
40	2	3
41	2	4
42	2	3
43	2	4
44	2	7
45	1	6
46	3	8
47	2	6
48	4	6
49	3	4
50	1	8