DEVELOPMENT OF INTERMEDIATE MOISTURE PRODUCT FROM WILD FIG

(*Ficus auriculata*)

Lakshmi,E.Jayachandran

Neethish Varghese

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DECLARATION

We hereby declare that this project report entitled "Development Of Intermediate Moisture Product From Wild Fig (*Ficus auriculata*)" is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of another University or Society.

Place:Tavanur

Lakshmi,E.Jayachandran

(2008-02-012)

Date:

Neethish Varghese

(2008-02-017)

CERTIFICATE

Certified that this project report, entitled**, "**Development Of Intermediate Moisture Product From Wild Fig (*Ficus auriculata*)" is a bonafide record of research work done jointly by Lakshmi,E.Jayachandran and Neethish Varghese under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Place: Tavanur

Date:

Dr. Santhi Mary Mathew

Professor

Dept of PHT & AP

KCAET, Tavanur

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Lakshmi, E.Jayachandran

Neethish Varghese

Dedicated to our Parents

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SYMBOLS AND ABBREIVIATIONS

%	percent
^0C	degree centigrade
^0B	degree Brix
Art.	Article
d.b.	dry basis
Eqn.	Equation
Et al	and others
Fig.	figure
g	gram
hr	hour
kg	kilogram
IMF	Intermediate Moisture Food
TSS	Total Soluble Solids
OA	Overall acceptability
S1	Sugar based candy (50^0B)
S2	Sugar based candy (60^0B)
S3	Honey based candy (72^0B)
S4	Control
a_w	Water activity

INTRODUCTION

CHAPTER-1

INTRODUCTION

A fruit is the edible, and more or less juicy, product of a tree or plant and consists of the matured ovary including its seeds and adjacent parts. Usually fruits are sweet, with a wide range of flavours, colours and texture.

Wild or nearly wild figs are reported throughout much of the Middle East and the tropical regions, but still remain underutilized. Wild fig usually occurs in the wind breaks of the forest, in forest clearings or at the edge of the rain forest, simply the places where the birds frequently roost. The young leaves are intensely red and start becoming more and more green when reaching their ultimate size of up to two feet in length. Although commonly referred to as the fruit, the fig, as eaten is actually the infructescence of the tree, known as a false fruit or multiple fruit, in which the flowers and seeds are borne. Fig trees have no blossoms on their branches. The blossom is inside the fruit. The genus name Ficus comes from the ancient Latin word ‘auricular’, a diminutive of ‘auris’ meaning “the ear” in reference to the large rounded lobes of the leaves that resemble an ear.

The wild fig is a highly valuable and highly nutritious fruit which has a great potential to be utilized by common man. The Wildlife Conservation Society of New York has recently determined that, in the plant and animal kingdom, the high calcium content of the wild fig makes it a “keystone” fruit, critical to the survival of other plants and animals. Of the common fruits, wild figs have the highest overall content of minerals, and their calcium content per serving is second to oranges. Also wild figs provide more fibre than all of the common fruits. A single serving contains 20% of the daily value of the fibre. Although considered a fruit, the fig fruit is the flower inverted into itself. They are the only fruits to ripen fully and semidry on the tree. Unfortunately these figs are not very popular among common man.

The reasons for the poor popularity of the wild figs are:

1. Lack of awareness about the nutritional profile
2. Lack of technology for value addition, through processing
3. Non availability of good quality planting materials
4. Lack of technology to reduce the gestation period and enhance the fruit production.
5. Highly perishable nature of the fruit

Most of these lesser known fruits establish through natural regeneration, grow slowly without any nutrition, start bearing fruits after a long period and produce fruits of inferior quality. Hence these species have remained neglected without any commercial importance. Most of these species are tolerant to harsh agro climatic conditions, hence they have an excellent potential for establishment on marginal and wastelands throughout the tropics. Commonly it is known as the Giant Indian Fig.

The tree bears fruits almost throughout the year, though ripening is prominent only during the summer months. The average yield of the tree is 32.4kg. The whole fruit tastes fairly sweet. The overall fruit quality is good. The fruit has a high potential for making value added products. The leaves of this tree are generally used as a fodder during the winter season. The leaves are also used as plates by stitching 3-4 leaves together for taking food during feasts in the villages.

Physiological maturity in a fruit can be defined as the stage of development where most growth has occurred, while ripeness suggests a readiness for consumption. On the other hand, horticultural or "commercial" maturity can be defined as the developmental stage where harvested fruit will undergo normal ripening and provide good eating quality. Fig being a climacteric fruit, its compositional changes at various stages of maturation was studied.The various quality parameters like TSS, moisture content, Calcium content, crude fibre content and acidity at were observed at each stage of maturity. The change in these parameters with the processing of the fruit was also studied.

In order to bring this underutilized, high potential fruit to the forefront, a study was undertaken to develop an IMF product by the method of Osmotic dehydration followed by further secondary drying using a cabinet dryer was adopted. It is a useful technique for the production of a safe, stable, nutritious, tasty, economical and concentrated food obtained by placing the solid food, whole or in pieces in sugar solutions of high osmotic pressure. The osmotic dehydration process utilizes the principle of water diffusion from dilute solution to concentrated solution through a semi permeable membrane until concentration equilibrium is reached.

Traditional intermediate moisture foods (IMF) can be regarded as one of the oldest foods preserved by man. The mixing of ingredients to achieve a given a_w, that allowed safe storage while maintaining enough water for palatability, was only done, however, on an empirical basis. The work done by food scientists approximately three decades ago, in the search for convenient stable products through removal of water, resulted in the so-called modern intermediate moisture foods. These foods rely heavily on the addition of humectants and preservatives to prevent or reduce the growth of microorganisms.

Keeping the above cited facts, a study was conducted with the following objectives:

a) To conduct the physico- chemical analysis of the wild fig at different stages of maturity.
b) To develop IMF products from wild fig.
c) Quality assessment and Sensory evaluation of the products developed.

REVIEW OF LITERATURE

CHAPTER-2

REVIEW OF LITERATURE

This chapter gives us a general information about the wild fig fruit, its chemical composition and also the literature relating to the below mentioned points.

1. Wild Fig-"Keystone fruit"
2. Nutritive and medicinal properties
3. Maturity studies in fruits
4. Fruits preserved under IMF concept
5. Osmotic dehydration of fruits
6. Preparation of candies

2.1 Wild Fig – "Keystone fruit"

The Wild fig (*Ficus auriculata* Loureira), an underutilized, highly nutritious fruit belongs to family Moracea. Its common names are Broadleaf fig, coconut-strawberry fig, Elephant ear fig, Eve's Apron, Giant Indian fig, Indian big leaf fig, Roxburgh fig

Both ripe and near ripe fruits are edible. Ripe fruits can be made into jams. In North-east India, the fruits are eaten raw. An evergreen to semi-deciduous, spreading large shrub or small tree reaching 25 feet tall and as wide with large oval shaped leaves as large as 15 inches in diameter.

2.2 Nutritive and medicinal properties

The methanol extracts of *Ficus auriculata* stem bark showed the presence of alkaloids, saponins, carbohydrates, glycosides, phytosterols, phenols, resins, diterpenes, tannins, flavanoids, proteins and amino acids (Ahlam El-Fishawy, et al.,2011). Mature fruits have digestion regulating properties and are laxative and diuretic in traditional medicine. Leaves and roasted fruits are used in treating diarrhea and dysentery. In India and Nepal, the leaves are crushed and the paste applied on wounds. Stem bark juice is effective for diarrhea, cuts and wounds. Root latex is used in treating mumps, cholera, diarrhea and vomiting. It is an important tree fodder in the Himalayan region of India and Nepal.

Fig is delicious, nutritive fruit and has medicinal properties such as reducing risk of cancer and heart disease. Fig fruit is consumed fresh, dried, preserved, canned and candied. In Mediterranean region, it is used for alcohol and wine production while in Europe for fig-coffee preparation. The period of availability of fig fruits commences in March, continues up to June, the peak period being April and May. Being highly perishable, fig cannot be stored for longer period at ambient condition. The dried figs can be stored for 6-8 months. Osmotic dehydration consists of partial removal of moisture from the produce by placing it in concentrated sugar solution. The product prepared by this method showed a porous crispy structure.

2.3 Maturity Indices in Fruits

Several processes take place as fruit ripen to become edible and then senescence. They may take place while fruit are still attached or after harvest. Fruit are regarded as ready to harvest once they 'mature' because they are then capable of normal ripening off the plant. Tomato, banana and avocado are examples of fruit that can be mature at picking yet totally inedible until subsequent ripening processes have occurred. In contrast, strawberries, oranges, boysenberries and grapes are examples of fruit that need to stay on the tree or vine until ready to eat in order to have their desired eating characteristics. Underlying differences in their physiology are outlined below.

The principles dictating at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage and marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest. At this point, the edible part of the fruit or vegetable is fully developed in size, although it may not be ready for immediate consumption. Ripening follows or overlaps maturation, rendering the produce edible, as indicated by taste. Senescence is the last stage, characterized by natural degradation of the fruit or vegetable, as in loss of texture, flavour, etc. (senescence ends at the death of the tissue of the fruit). Some typical maturity indexes are described in following sections.

2.3.1 Skin colour:

This factor is commonly applied to fruits, since skin colour changes as fruit ripens or matures. Some fruits exhibit no perceptible colour change during maturation, depending on the type of fruit or vegetable. Assessment of harvest maturity by skin colour depends on the judgment of the harvester, but colour charts are available for cultivars, such as apples, tomatoes, peaches, chilli peppers, etc.

2.3.2 Optical methods:

Light transmission properties can be used to measure the degree of maturity of fruits. These methods are based on the chlorophyll content of the fruit, which is reduced during maturation. The fruit is exposed to a bright light, which is then switched off so that the fruit is in total darkness. Next, a sensor measures the amount of light emitted from the fruit, which is proportional to its chlorophyll content and thus its maturity.

2.3.3 Shape:

The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops on the plant. Mangoes also change shape during maturation. As the mango matures on the tree the relationship between the shoulders of the fruit and the point at which the stalk is attached may change. The shoulders of immature mangoes slope away from the fruit stalk; however, on more mature mangoes the shoulders become level with the point of attachment, and with even more maturity the shoulders may be raised above this point.

2.3.4 Size:

Changes in the size of a crop while growing are frequently used to determine the time of harvest. For example, partially mature cobs of *Zea mays saccharata* are marketed as sweet corn, while even less mature and thus smaller cobs are marketed as baby corn. For bananas, the width of individual fingers can be used to determine harvest maturity. Usually a finger is placed midway along the bunch and its maximum width is measured with callipers; this is referred to as the calliper grade.

2.3.5 Aroma:

Most fruits synthesize volatile chemicals as they ripen. Such chemicals give fruit its characteristic odour and can be used to determine whether it is ripe or not. These doors may only be detectable by humans when a fruit is completely ripe, and therefore has limited use in commercial situations.

2.3.6 Fruit opening:

Some fruits may develop toxic compounds during ripening, such as ackee tree fruit, which contains toxic levels of hypoglycine. The fruit splits when it is fully mature, revealing black seeds on yellow arils. At this stage, it has been shown to contain minimal amounts of hypoglycine or none at all. This creates a problem in marketing; because the fruit is so mature, it will have a very short post-harvest life. Analysis of hypoglycine 'A' (hyp.) in ackee tree fruit revealed that the seed contained appreciable hyp. at all stages of maturity, at approximately 1000 ppm, while levels in the membrane mirrored those in the arils. This analysis supports earlier observations that unopened or partially opened fruit should not be consumed, whereas fruit that opens naturally to over 15 mm of lobe separation poses little health hazard, provided the seed and membrane portions are removed. These observations agree with those of Brown et al. (1992) who stated that bright red, full sized pack should never be forced open for human consumption.

2.3.7 Leaf changes:

Leaf quality often determines when fruits and vegetables should be harvested. In root crops, the condition of the leaves can likewise indicate the condition of the crop below ground. For example, if potatoes are to be stored, then the optimum harvest time is soon after the leaves and stems have died. If harvested earlier, the skins will be less resistant to harvesting and handling damage and more prone to storage diseases.

2.3.8 Abscission:

As part of the natural development of a fruit an abscission layer is formed in the pedicel. For example, in cantaloupe melons, harvesting before the abscission layer is fully developed results in inferior flavoured fruit, compared to those left on the vine for the full period.

2.3.9 Firmness:

A fruit may change in texture during maturation, especially during ripening when it may become rapidly softer. Excessive loss of moisture may also affect the texture of crops. These textural changes are detected by touch, and the harvester may simply be able to gently squeeze the fruit and judge whether the crop can be harvested. Today sophisticated devices have been developed to measure texture in fruits and vegetables, for example, texture analyzers and pressure testers; they are currently available for fruits and vegetables in various forms. A force is applied to the surface of the fruit, allowing the probe of the penetrometer or texturometer to penetrate the fruit flesh, which then gives a reading on firmness. Hand held pressure testers could give variable results because the basis on which they are used to measure firmness is affected by the angle at which the force is applied. Two commonly used pressure testers to measure the firmness of fruits and vegetables are the Magness-Taylor and UC Fruit Firmness testers.

2.3.10 Specific gravity:

Specific gravity is the relative gravity, or weight of solids or liquids, compared to pure distilled water at 62°F (16.7°C), which is considered unity. Specific gravity is obtained by comparing the weights of equal bulks of other bodies with the weight of water. In practice, the fruit or vegetable is weighed in air, then in pure water. The weight in air divided by the weight in water gives the specific gravity. This will ensure a reliable measure of fruit maturity. As a fruit matures its specific gravity increases. This parameter is rarely used in practice to determine time of harvest, but could be used in cases where development of a suitable sampling technique is possible. It is used however to grade crops according to different maturities at post-harvest. This is done by placing the fruit in a tank of water, wherein those that float are less mature than those that sink.

2.3.11 Acidity:

In many fruits, the acidity changes during maturation and ripening, and in the case of citrus and other fruits, acidity reduces progressively as the fruit matures on the tree.

2.3.12 Water:

After harvest, during storage and ripening, fruit and vegetable lose water as a result of respiration transpiration and exchange of gas, resulting in water loss. Loss of H_2O depends upon the RH, temperature, anatomical structure and the rate of transpiration and respiration. When the loss is more than 5-10% fruit and vegetable start shrivel and become unusable.

2.3.13 Colour:

The most common change is loss of green colour. It is due to degradation of chlorophyll structure. The degradation is due to pH, oxidative systems. The disappearance of chlorophyll is associated with the synthesis of pigments ranges from yellow to red.

Palmer(1971) by experience, judged the visual appearance of the hanging bunch and particularly by the angularity of individual fingers in banana.

Dann and Jerie (1988) conducted studies on the variation of TSS with maturity of fruits. They concluded that the TSS increases with maturity. Use of SSC as a maturity index alone is limited by variation among varieties, production area and season.

Dhillon and Cheema (1991) found that with the delay in harvesting, a rapid increase on the TSS:Acid ratio is seen in peacvh 'Flordasun' , due to sharp increase in TSS and corresponding decrease in the acidity, with maturity.

Horvat and Chapman (1990) observed that as a fruit ripens, it softens , its acidity declines and it produces certain volatile compounds that give it its characteristic aroma.

Dadzie (1993) found that there is both a linear relationship and a strong correlation between pulp to peel ratio and bunch age in different varieties of banana.

Abu-Goukh and Abu-Sarra (1993)observed an increase in the TSS and titratable acidity in different variants of mango.

Undurraga-Martinez (1995) observed that during the development of avocado fruit, the oil content increases and moisture content rapidly decreases.

Youming Wang *et al* (1996) observed changes in the aroma volatiles, free amino acids, sugars, principle acids and soluble minerals were studied during the development and ripening of the melons. The changes in the TSS during ripening showed close correlation with those found for the pH, ceratin amino acids and certain elements like sodium and potassium.

Hussein *et al* (2001) observed a progressive increase in the TSS: Acid ratio with the increase in the maturity of apple till the fruits reach the optimum maturity stage after which it starts decreasing.

Hind a Bashir *et al* (2002) studied the compositional changes in the fruit pulp and peel during ripening of white and pink fleshed guava fruits. The white and pink fleshed guava fruits exhibit a climacteric pattern of respiration. Fruit tissue firmness decreased progressively whereas the TSS and the sugars increased in the pulp and the peel of the guava fruit. Titratable acidity increased up to the full ripe stage and then decreased.

W.N.Sawaya (2006) studied the compositional changes during the fruit maturation in two important date cultivars grown in Saudi Arabia. Physical analyses showed that the fruit weight, length, diameter and weight of the seed were the highest at the mature color stage. Chemical analyses including the moisture, total nitrogen, fat, fibre, and ash, tannins, Vitamin C, Beta carotene and 10 nutritionally essential minerals showed that all were highest at the early stages of development and decreased during maturation. Reducing sugars were dominant in both cultivators and showed progressive increase during ripening with fructose and glucose as the only detected constituents. Sucrose content reached its maximum in both cultivators at the mature color stage then dropped sharply at the ripe stage. The total sugar content in both cultivators tended to increase all throughout maturation.

M.S Ladaniya *et al* (2011) studied the fruit maturity changes in terms of physical, chemical, physiological, and sensory characteristics 'Mosambi' orange grown under sub humid tropical climate of central India were studied. Rapid increase in fruit diameter, volume and weight was recorded from 180 to 220 days after fruit set, however the growth was slow thereafter up to 250 days, respectively. Fruit firmness, peel thickness, peel and rag percentage decreased, while peel colour, TSS/acid ratio and juice content increased. Vitamin 'C' content was 56.60 mg/100ml initially and decreased to 52mg/100ml as fruit matured. The pH of the juice increased with fruit maturity. Fruits developed acceptable flavor .Chlorophyll ('a','b' and total) content dropped and total carotenoid in rind flavedo increased significantly. Reducing and total sugars in juice increased. Respiratory rate declined with fruit maturity confirming non-climacteric nature of, Mosambi fruit.

Narendra Narain(1991) analysed the fruits of the umbu (spondias tuberose arruda Camara), also known as 'imbu' in English,for some physical and chemical changes during various stages of maturity. The fruit was found to be round to ovoidal in shape, being on average,3.21cm long and 2.86 cm in width. Half-ripe fruits contained the maximum (64.62%) pulp content. The pH of the fruits increased with the advance in maturity and ripe fruits were significantly less acidic than green mature and half-ripe fruits. Ripe and half-ripe fruits contained significantly higher reducing sugars(5.34 and 4.14% respectively) than green mature(2.79%) fruits.

Gokham Durmaz et al (2010) examined five apricot (prunus armeniaca L) cultivars throughout fruit development period to monitor the changes in quality characteristics including hardness, Brix, color, titratable acidity and pH. Changes in the amount of sugar (fructose, glucose and sucrose) and organic acids (citric,malic and quinic) were also determined by HPLC.

2.4. Fruits Preserved Under IMF Concept

The application of IMF technology has been very successful in preserving fruits and vegetables without refrigeration. For instance, the addition of high amounts of sugar to fruits during processing will create a protective layer against microbial contamination after the heat process. The sugar acts as a water activity depressor limiting the capability of bacteria to grow in food.IMF foods are those with a_w in the range of 0.65 to 0.90 and moisture content between 15% and 40%. Food products formulated under this concept are stable at room temperature without thermal processing and can be generally eaten without rehydration. Some processed fruits and vegetables are considered IMF foods. These include cabbage, carrots, horseradish, potatoes, strawberries, etc.; their water activities at 30°C follow:

Foods	**a_w**
Cabbage	0.64
	0.75
Carrots	0.64
	0.75
Potatoes	0.75
	0.64
Strawberries	0.65
	0.75

Table 2.1 Water activity of different vegetables

Under these conditions, bacterial growth is inhibited but some moulds and yeast may grow at a_w greater than 0.70. In addition, chemical preservatives are generally used to inhibit the growth of moulds and yeasts in fruits and vegetables. The importance of considering the combined action of decreased water activity with other preservation factors as a way to develop new improved foodstuffs has been studied.

2.4.1 Advantages and disadvantages of IMF preservation

Advantages:

Intermediate moisture foods have an a_w range of 0.65-0.90, and thus water activity is their primary hurdle to achieving microbial stability and safety. IMF foods are easy to prepare and store without refrigeration. They are energy efficient and relatively cheap. They are not readily subject to spoilage, even if packages have been damaged prior to opening, as with thermo stabilized foods, because of low a_w. This is a plus for many developing countries, especially those in tropical climates with inadequate infrastructure for processing and storage, and offers marketing advantages for consumers all over the world.

Disadvantages:

Some IMF foods contain high levels of additives (i.e., nitrites sulphites, humectants, etc.) that may cause health concerns and possible legal problems. High sugar content is also a concern because of the high calorific intake. Therefore, efforts are been made to improve the quality of such foods by decreasing sugar and salt addition, as well as by increasing the moisture content and a_w, but without sacrificing the microbial stability and safety of products if stored without refrigeration. This may be achieved by an intelligent application of hurdles.

Leistner (1994) introduced the hurdle concept, or hurdle effect, to illustrate the fact that in most foods, a combination of preservation parameters (hurdles) accounts for their final microbial stability and safety. Since then, these concepts have been improved to the point that depending on the acting hurdles of high relevance to a particular product, shelf-stability can be accomplished by a careful handling of complementary hurdles. For instance, the pH of IMF should be as low as palatability permits, and whenever possible, below pH 5.0. Undoubtedly, this imposes a limitation not only on colonizing microflora, but also on foodstuffs, since pH cannot be reduced in many products without flavour impairment. Even at low pH values and low a_w, certain yeast and mould species that can tolerate high solute concentrations might pose a risk to the stability of IMF.

Fruits are a good example of foodstuffs that accept pH reduction without affecting the flavour significantly. Important developments on IMF based on fruits and vegetables are reported elsewhere. The extensive research conducted in India by

Jayaraman *et al* (1992) has generated important information on this product category. Technological problems have prevented IMF from further development. Also, consumer health concerns associated with the high levels of humectants and preservatives used, have contributed to this situation. This last issue has become more important in recent years due to greater public awareness of food safety concerns. Additionally, consumers are searching for fresh-like characteristics in products. The food industry has responded to these demands with the so-called minimally processed fruits and vegetables, which have become a widespread industry. Consequently, safety considerations are being addressed seriously by food microbiologists.

Different approaches can be explored for obtaining shelf-stability and fresh-likeness in fruit products. Commercial, minimally processed fruits are fresh (with high moisture), and are prepared for convenient consumption and distribution to the consumer in a fresh-like state. Minimum processing includes preparation procedures such as washing, peeling, cutting, packing, etc., after which the fruit product is usually placed in refrigerated storage where its stability varies depending on the type of product, processing, and storage conditions. However, product stability without refrigeration is an important issue not only in developing countries but in industrialized countries as well. The principle used by Leistner for shelf-stable high moisture meats (a_w >0.90), where only mild heat treatment is used and the product still exhibits a long shelf life without refrigeration, can be applied to other foodstuffs. Fruits would be a good choice. Leistner states that for industrialized countries, production of shelf-stable products (SSP) is more attractive than IMF because the required a_w for SSP is not as low and less humectants and/or less drying of the product is necessary.

If fresh-like fruit is the goal, dehydration should not be used in processing. Reduction of a_w by addition of humectants should be employed at a minimum level to maintain the product in a high moisture state. To compensate for the high moisture left in the product (in terms of stability), a controlled blanching can be applied without affecting the sensory and nutritional properties; pH reductions can be made that will not impair flavour; and preservatives can be added to alleviate the risk of spoilage by microflora. In conjunction with the above mentioned factors, a slight thermal treatment, pH reduction, slight aw reduction and the addition of antimicrobials (sorbic or benzoic acid, sulphite), all placed in context with the hurdle principle applied to fruits, make up an interesting alternative to IMF preservation of fruits, as well as to commercial minimally processed fruits.

Alzamora et al. (1995) conducted pioneer work aimed at obtaining shelf-stable peaches and pineapple. Considerable research has been made within the CYTED Program and the Multinational Project on Biotechnology and Food of the Organization of American States (OAS) in the area of combined methods geared to the development of shelf-stable high moisture fruit products.

Over the last decade, use of this approach has led to important developments of innovative technologies for obtaining shelf-stable "high moisture fruit products" (HMFP) storable for 3-8 months without refrigeration. These new technologies are based on a combination of inhibiting factors to combat the deleterious effects of microorganisms in fruits, including additional factors to diminish major quality loss in reactions rates. Slight reduction of water activity (a_w 0.94-0.98), control of pH (pH 3.0-4.1), mild heat treatment, addition of preservatives (concentrations £ 1,500 ppm), and anti browning additives were the factors selected to formulate the preservation procedure. These techniques were preceded by the pioneer work of Leistner (1994) on the combined effects of several factors applied to meat products - named "hurdle" technology.

Microbiological preservation with these combined techniques, by gently applying individual stress factors to control microbial growth, avoid the severity of techniques based on the employment of only one conservation factor.

2.5 Osmotic Dehydration of Fruits

In osmotic dehydration of fruits, the method involves the partial dehydration of fruits by osmosis in a concentrated sugar solution or syrup. The moisture is drawn out from all cell tissues. The water is then bound with the solute, making it unavailable to the microorganisms. In the osmotic dehydration of fruits, the method involves the partial dehydration of fruits by osmosis in concentrated sugar solution or syrup.

Fruits such as apple, banana, cherry, mango, papaya, pineapple, plum, etc.can are dehydrated by osmosis. Osmotic dehydration can remove 30-50% of the water from fresh ripe fruits e.g. mangoes, pineapple, banana, sapota and papayas. The final drying of these osmotically dehydrated fruits by vacuum drying provides a product which has good quality attributes with respect to appearance, taste, flavour and colour as compared to sun drying. It is simple and improved method of dehydration which can be adopted even in rural areas without much investment on machinery. As the process is carried out at mild temperatures and the moisture is removed by a liquid diffusion process, phase change that would be present in the other drying process will be avoided, resulting in high quality products and may also lead to substantial energy savings.

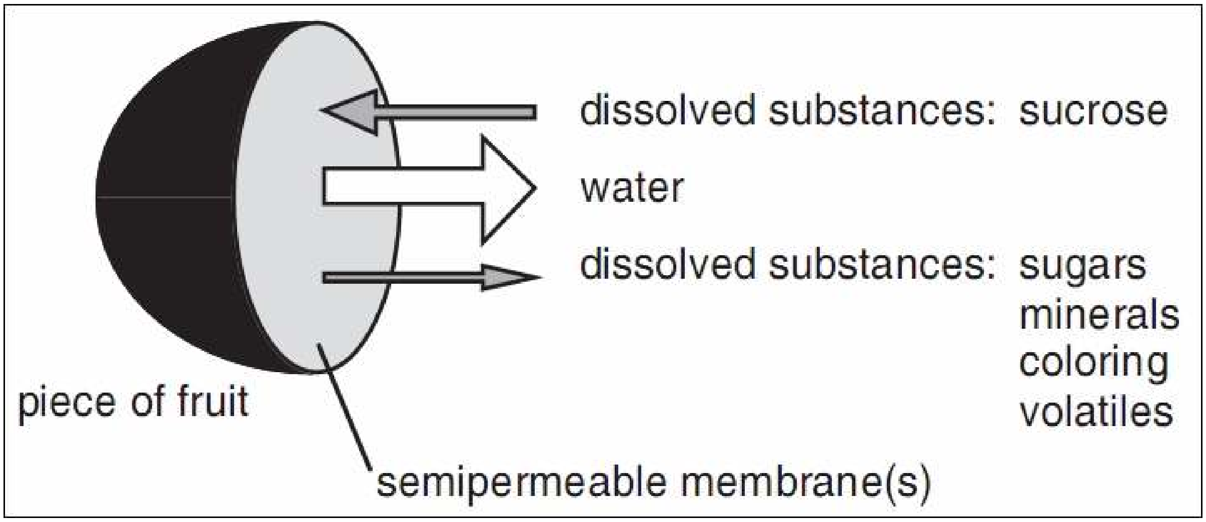

Fig 2.1 Osmotic dehydration process

ADVANTAGES OF OSMOTIC DEHYDRATION

1. Minimum loss of colour and flavour
2. Browning is prevented
3. Sweetening of the product
4. Reduces the water removal load
5. Increases the solid density of the product
6. Textural quality will be better
7. Simple facility and equipment
8. Less expensive process

LIMITATIONS OF OSMOTIC DEHYDRATION:

1. The reduction in acidity level reduces the characteristic taste of some products
2. Sugar uptake may not be desirable in certain product.

Factors influencing osmotic dehydration:

1. Pre-treatments
2. Osmotic agents
3. Concentration
4. Temperature
5. Agitation/circulation
6. Duration of osmosis
7. Size and thickness

The product is suitable as a ready to eat snack item. Also the dehydrated product could be powdered if desired, and mixed with milk powder for making other products and confectionery items.

SUILTABILITY OF A FRUIT TO BE PROCESSED

Practically any fruit and vegetable can be processed, but some important factors which determine whether it is worthwhile are:

1. The demand for a particular fruit and vegetable in the processed form;
2. The quality of the raw material/ i.e. whether it can withstand and processing
3. Regular supplies of the raw material.

Fruits in general contain more than 75% water and get spoiled very quickly, if not stored properly. Even proper storage fails to preserve the fruits for a long period unless they are dehydrated. The osmotic dehydration techniques not only enables the storage of the fruits for a longer period, but also preserves flavor , nutritional characteristics and prevents microbial spoilage. Apart from this, problems of marketing, handling and transport becomes much simpler and all types of fruits could be made available to the consumer throughout the year. Osmotic dehydration can remove 50% of the water from fresh ripe fruits e.g. bananas, mangoes, sapotas, papayas, apples and other tropical fruits. The final drying of these osmotic dehydrated fruits by vacuum drying provides a product which has good quality, attributes with respect to appearance, taste, flavor and colour as compared to sun drying. The product is suitable as a ready to eat snack item. Also the dehydrated product could be powdered if desired, and mixed with milk powder for making other products and confectionery items. The process of dehydration consists of three steps i) Osmotic dehydration, ii) Vacuum or air drying, iii) Packaging. In osmotic dehydration, the fruits are subjected to osmosis by dipping or spreading them in a aqueous sugar syrup under specific conditions, so that the water from the fruits migrates to sugar syrup. Major dehydration of the fruit takes place in this process step.

Contreras and Smyrl(1981) made an evaluation concentration of apple rings using corn syrup solids solution. It was found that weight loss in apple was promoted by increased corn syrup solids concentration, increased immersion time, increased temperature and decreased thickness. Results showed that the weight of the apple rings was reduced by 70% during osmotic dehydration.

Angela et al (1987) made a combination process osmotic dehydration and freeze drying to produce a raisin type blue berry product. The product was made using berry: sugar ratio of 3:1 or 4:1 for osmotic dehydration followed by freez drying. The final product had a good texture, flavor, acceptability and a predicted shelf life of 16 and 64 months at 25-50 degree Celsius respectively.

Kim and Toledo (1987) found out the effect of osmotic dehydration and high temperature fluidized Bed drying, on the properties of rabbiteye blue berries. HTFB Drying reduced dehydration time compared to conventional dehydration. The dried product has less bulk density, larger diameter, faster rehydration time and higher rehydration ratio. HFTB increased drying rate and prevented sticking of blueberries thereby facilitating final drying of osmotically dehydrated blueberries.

Vyas and Sharma (1989) applied osmotic technique in plum wine fermentation. Compared to untreated fruits, wines of acceptable acidity were produced from most of the pre-treated fruits. Water blanching of plums followed by osmotic treatment improved the sensory qualities of plum wine in reducing excessive acidity and astringency.

Tomar et al (1990) conducted osmotic dehydration of pear. Treatment was done by steeping pear rings in 400,500 and 700 B sugar at 100 degree celcius, containing 0.2% citric acid. Pear rings steeped in 600 B were found significantly superior in flavor, texture and taste compared to other treatments. Rings steeped in 700 B were rated second. Unsteeped dehydrated rings showed hard texture, unattractive colour and unbalanced acid-sugar ratio.

Raoult et al (1992) made a study on the recent advances in dewatering through immersion in concentrated solutions. He found that this 2 fold transformation of pieces might provide aside from improved organoleptic qualities, an energy efficient removal for water removal before any further water activity lowering treatment.All kinds of dewatering and impregnation soaking processes and evenly candying, semi-candying , salting and curing could benefit from these advances.

Fito et al (1994) conducted osmotic dehydration trials in a pilot plant with pressure and temperature control(Kiwi slices were immersed in the tank containing the osmotic solution. A recirculation pump connected to the tank allowed good agitation of the osmotic solution. The system was subjected to vacuum conditions; the duration of the vacuum pulses were 0, 5, 10 and 15 min. After that, the atmospheric pressure was then restored and samples held for 0, 15, 30, 45, 60, 120 and 180 mins. Experiments were conducted at different temperatures (25, 35 and 45^0C) and using two kinds of osmotic solutions, sucrose and concentrated grape juice. Experiments were repeated in triplicate; moisture content, Brix and weight were determined in all samples before and after the osmotic treatment. The results were analysed by ANOVA using Statgraphics Plus 4 Software(Statgraphics 1998).

Pokharkar and Mahale (1998) found out that banana slices that were osmotically dehydrated with sugar solution were chewy and maintained its bright yellow colour compared to the untreated slices which were and had dull brown appearance.

Rastogi and Niranjan(1998) made a study on the enhanced mass transfer during osmotic dehydration of pineapple by high pressure ttreatment. Diffusivity of water and solute in high pressure treated pineapple slices was found higher. The diffusivity increased with treatment pressure upto 400 MPa above which it did not vary significantly. The increase was attributed to breaking up of cellwalls, which facilitated the transport of water.

Reppe *et al* (1998) conducted experiments on osmotically dehydrated apples and found that the sugar gain was greater with decrease in solute molecular weight. Glucose uptake by apple was significantly higher than that of sucrose.

Rastogi and Raghavarao (2003) studied the osmotic dehydration kinetics of pineapple cubes over a range of concentration (40-70^{0}Brix) and temperature (30-50^{0}C) of osmotic solution.

Viberg *et al*(1998) studied about the osmotic pretreatment of strawberries and shrinkage effects. Aqueous sucrose solutions (20-80%w/w) and granulated sucrose were used as the osmotic medium. Pretreatment in 60% (w/w) sucrose solution gave the best results of increased density combined with a small decrease in volume. The use of granulated sucrose resulted in greater shrinkage. Subsequent thermal processing did not notably change the volume of pretreated strawberries.

Abhijit and sanjaya (1999) made a study on the details of osmotic dehydration in food processing industries. It was found that the best osmotic effect was obtained at solution to sample ratios of 4:1 to 6:1.

Sharma and Lal (1999) studied about the effect of partial osmotic dehydration prior to canning on the drained weight and quality of three varieties of plum. Fruits of plum cultivars Red Ace, Burbank-A and kanto-5 were canned in 350B syrup, with or without the addition of calcium ions after osmotic dehydration for 0,0.5,1 or 1.5 h in 700B sugar solution at 500C. Cut out analysis after 1year of storage indicated that fruits which were given an osmotic dehydration treatment for 1 h prior to canning showed the desired draned weight in addition to improved colour, texture and taste compared to fruits canned by traditional methods.

Amithabh et al (2000) conducted studies on the osmotic dehydration of some varieties of ripe mangoes grown in Uttar Pradesh. The effect of osmotic dehydration on 4 mango varieties, keeping the concentration, volume and temperature of the sugar syrup constant was evaluated. The only variable added was the percentage of added citric acid. The storage studies showed that keeping the osmotic dehydrated mango slices above 64.8 and below 75.5% RH would to conducive to the retention of the colour , flavor, taste and the texture of the product.

Ambily *et al (*2002) conducted studies on the osmotic dehydration of banana (Nendran variety) and concluded that the concentration of 70^0Brix followed by secondary drying using a vacuum dryer gave superior quality products.

Pan et al (2003) found that the addition of a small amount of sodium chloride to different sugar solutions in several vegetables and fruits (apple , carrot, ginger and pumpkin) dehydration led to a higher dehydration rate without increasing solids gain considerably.

Gawade and Waskar (2003) found that dried figs prepared from ‘Poona’ and ‘Dinkar’ varieties could be stored for more than 180 days at low temperature, which maintained physic-chemical characteristics and rated highest organolpetic score for better market acceptability.

Gurumeenakshi et al (2005) reported the osmotic concentration process for mango and papaya slices on sugar syrup of 60 degree Brix for 18h and packed in metalized polypropylene covers for storage up to 6months. There were little changes in chemical, physical and sensory properties and consumer acceptability was high during storage period.

Madan and Dhawan (2005) prepared osmo-dried carrot slices by soaking in sugar syrup for 3h and drying at 60 degree Celsius for 15h and reported higher retention of carotene .

Rashmi et al. (2005) studied on osmo air dehydration of pineapple fruits in 70 degree Brix sugar syrup and reported removal of significant amount of moisture.

Sachadev et al.(2007) studied the osmotic dehydration of apple slices by using 50 and 70^0 Brix osmotic solution and KMS and blanching as pretreatments and reported that samples treated with KMS for 15min with 50 degree Brix osmotic syrup found to be better .

Dhingra et al. (2008) reviewed that osmotic dehydration of fruits and vegetable has the potential to extend their shelf life. The products obtained by osmotic dehydration are more stable during storage due to low water activity imparted by solute gain and water loss.

Narwirska et al. (2009) compared a few drying methods (convective, vacuum-microwave, vacuum and freeze drying) on the drying kinetics and quality of 12 pumpkin cultivars. They reported vacuum-microwave drying produced pumpkin slice with more attractive colour.

Heredia et al (2009) found that Osmoactive substances such as sucrose and sodium chloride could preserve and even increase the lycopene and beta carotene content of cherry tomato by affecting the integrity of the cellular matrix.

De Escalada Pla et al. (2009) reported pumpkin (*Cucurbita moschata* Duchesne ex poiret) mesocarp tissue is suitable to be a fiber-rich food matrix for iron supply after soaking in Fe2+ rich osmotic solution.

2.6 Preparation of Fruit Candies

Candy is a sweet food prepared from fruits or vegetables by the principle of osmotic dehydration in sugar syrup and then drying the product to a shelf stable state. Fruits and vegetables like apple, ginger, mangoes, carrots and citrus peels have been used to prepare candies.

White sugar is the usual sweetening agent used in preparation of candies. Such sugar contains sucrose (99.7%). Excessive consumption of sucrose quite often leads to variety of health problems viz. heart problems and coronary thrombosis. Keeping in view the disadvantages associated with excessive sugar with alternate natural and artificial sweeteners.

Honey is a natural sweetener which is valued as food due to its high energy carbohydrate content, considered to be best source of heat and energy and preferred as vehicle of medicine because of its freedom from any adverse effect and assimilation. Honey has antimicrobial and antifungal properties also. Growth of bacterial species such as *Eschericia coli, staphylococcus aureus, Salmonella typhimurium* ***and*** *Shigella sp*. are controlled by honey while its antimicrobial characteristics are due to osmotic effect, acidity, H_20_2, flavonoids and aromatic acidic substances. Honey also has antioxidation properties.

Madan and Dhawan (2005) have developed carrot candies by using sugar and jaggery syrups. Fresh coconut powder was used for enrolling sugar candies. Such candies, even on 60th day of storage at room temperature when packed in polythene bags scored above 7 on a 9=point Hedonic state for sensory attributes.

Srivastava et al. (2006) have recently developed jiggery based petha (Ash gourd) candy, which could be stored for 45days under refrigerated condition.

Verma et al. (2006) have developed Amla murabba (preserve) by using honey and found both the fresh and preserved honey based murabba had pleasant flavor ,taste, colour, texture and overall acceptability and could be safely preserved for 6months at room temperature in glass andpet jars.

MATERIALS AND METHODS

CHAPTER-3
MATERIALS AND METHODS

In this chapter the preparation of raw materials, osmotic agent and the experimental procedures are presented. The materials required are also explained in detail.

3.1Test Sample

This study was undertaken on wild fig fruits at 3 different stages of maturity. The fruit was procured from the tree growing in the KCAET Campus as well as from the College of Horticultural, Vellanikkara. The tree is seen to bear fruits almost throughout the year.

3.2Peeling and sizing

The ripe fig fruits were washed thoroughly with water to remove the extraneous matter. Damaged ones were culled out. It was peeled manually and sliced transversely to a uniform thickness of 3 mm using a sharp knife. Moisture content, TSS, Titratable acidity, crude fibre, calcium, and the colour changes were determined at different stages of maturity, using standard procedures.

3.3Physico-chemical analysis of fig fruits at different maturity stages

The maturity studies were conducted on the wild fig fruit which remains underutilized till date, inspite of its medicinal and therapeutic uses. The three different maturity stages , such as 30 days, 60 days and 90 days after flowering were selected for this study and maturity studies conducted on them, mainly in the context of its composition. The physico – chemical analysis of the fruits were done on the basis of the following parameters:

3.3.1Total Soluble Solids

A hand refractometer (0-32) was used to determine the TSS. A sample of about 5g from each fruit and were mashed to form a paste and the Brix determined for each of them.

3.3.2 Moisture Content

The moisture content was determined using the Oven drying method. The samples obtained from the three different fruit stages were mashed and then kept in the oven dryer at 60^0C for 24 h (Ranganna,S. , 1991).

$$\text{Moisture content (w.b\%)} = \frac{wm}{wd} \times 100$$

Where, w_m-Weight of the moisture (g)
w_d- Weight of the sample (g)

3.3.3 Titratable acidity

The acidity in the sample is determined by titrating a given sample against a standard alkali solution using phenolphthalein as an indicator (Ranganna , 1991). Appearance of light pink colour is taken as the end point; Phenolphthalein gives a colour in a medium pH range of 8 – 9.6. It is colourless in acidic medium.

$$\text{\% Titratble acidity} = \frac{Titre\ value\ x\ Normality\ of\ NaOH\ x\ Vol\ made\ up\ x\ Equivalent\ weight\ of\ acid}{Vol\ of\ sample\ taken\ for\ estimation\ x\ Weight\ of\ sample\ taken\ x\ 1000}$$

3.3.4Crude fibre

Crude fibre consists of the cellulose, variable proportion of hemicelluloses and highly variable proportion of lignin along with some minerals. Estimation is based on the titration of the moisture and fat free sample successively with dilute acid and alkali (Ranganna, 1991).

$$\text{\% Crude fibre} = \frac{Loss\ in\ weight\ on\ ignition}{Weight\ of\ sample} \times 100$$

3.3.5 Calcium content

It is estimated by precipitating Calcium oxalate, followed by washing the precipitate and dissolving it in sufficient amount of 2N H_2SO_4 and titrating it against 0.01 N $KMnO_4$.

$$\text{Ca content/100 ml ash solution} = \frac{0.2\ x\ Titre\ value\ x\ 100}{10}\ \text{mg of Ca}$$

3.4 Preparation of IMF Products.

Fruit products from intermediate moisture foods (IMF) appear to have potential markets. However, application of this technology to produce stable products at ambient temperature is limited by the high concentration of solutes required to reduce water activities to safe levels. This usually affects the sensory properties of the food.

3.4.1 Preparation of the hypertonic solution

The study was conducted using sugar solution at 50^0 and 60^0Brix, and honey which is at 70^0Brix as the osmotic agents. Fruit to solution ratio was taken as 1:4. The sugar syrup of required concentration was prepared, filtered and its TSS was checked using a Hand refractometer.

3.4.2 Experimental Procedure

The fully matured, fresh fig fruits were sliced transversely in 3 mm thickness and kept immersed in the above mentioned hypertonic solutions, till the TSS remained constant, as per the standard procedure explained by Srivastava,R.P and Kumar Sanjeev (1990). This was followed by the secondary drying using a cabinet dryer at 60±1^{o}C till the weight became constant. After drying the products were packed airtight and stored for further quality analysis.

3.5 Quality Analysis of IMF Product

The quality of the prepared products were analysed in terms of TSS, Moisture content, Acidity, Ca- content, Crude fibre content and the colour as per the standard procedure and it was compared with the fig (*Ficus carica*) which is available in the market. The sensory evaluation of the prepared products was also conducted on a 9 point Hedonic rating scale as given in Appendix 3.

Plate 3.1 Cabinet dryer

RESULTS AND DISCUSSION

CHAPTER-4
RESULTS AND DISCUSSION

This study was undertaken to observe the effect of the physio-chemical composition with different stages of maturity and also to develop an IMF product to utilize this highly nutritious, underutilized fruit. This chapter highlights the results of various experiments and the quality evaluation of the final product.

4.1 Test Sample

The fresh fruits at different stages of maturity were anlaysed by the standard procedure as mentioned in chapter 3 and the results were tabulated.

1.	TSS	7
2.	Acidity (%)	0.2235
3.	Crude fibre (%)	15.5
4.	Calcium (mg/100g)	50
5.	Moisture content(%)	87.1
6.	Colour	Red

Table 4.1 Composition of Fresh Ripe Fig Fruits

4.2 Physico-chemical analysis of fig fruits at different maturity stages

Results of the experiments carried out on the different parameters of the fig fruit at different stages of maturity (30, 60 and 90 days after flowering) have been tabulated as below:

From the above Fig 4.1, it is seen that the TSS content increases with the fruit maturation This increase in TSS can be attributed to the conversion of the starch into sugar. But the TSS was comparatively less, than that in the common fig. A similar trend was also reported by Sawaya(2006) for different cultivars of dates.

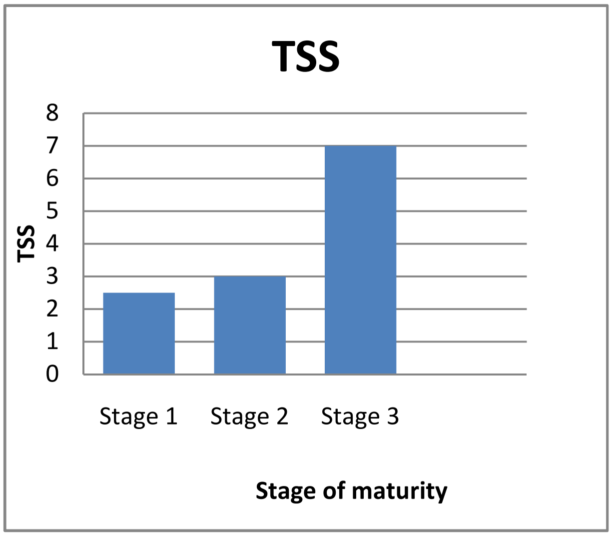

Fig 4.1 TSS-Stage of maturity

The titratable acidity of the fruit remained more or less the same with each stage of maturity. Generally, the fig fruits contain the malic acid. The pH of the fig fruit extract is about 4.3-4.5.This is seen in Fig 4.2

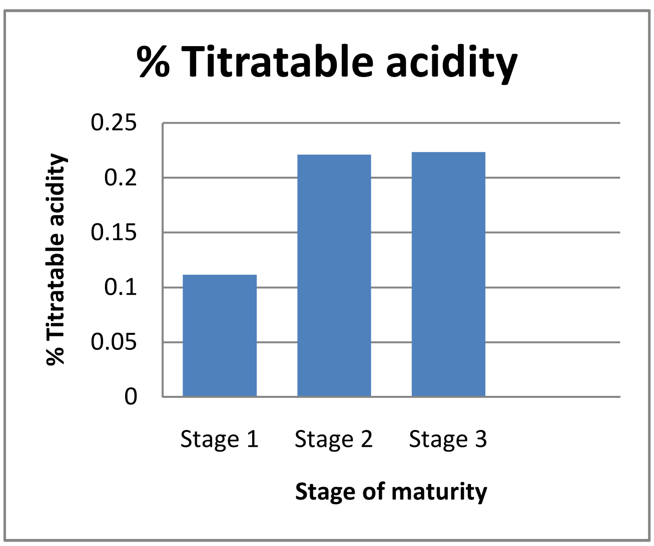

Fig 4.2 %Titratable acidity –Stage of maturity

The crude fibres are usually connotated with the insoluble, non-nutritive portion of the fruit flesh, and mainly composed of cellulose, hemicellulose, lignins and ligno-cellulose, and insoluble proteins. Fig 4.3 shows that the crude fibre content of the fruit was low in the initial stages but remained more or less the same in the intermediate and ripened stages.

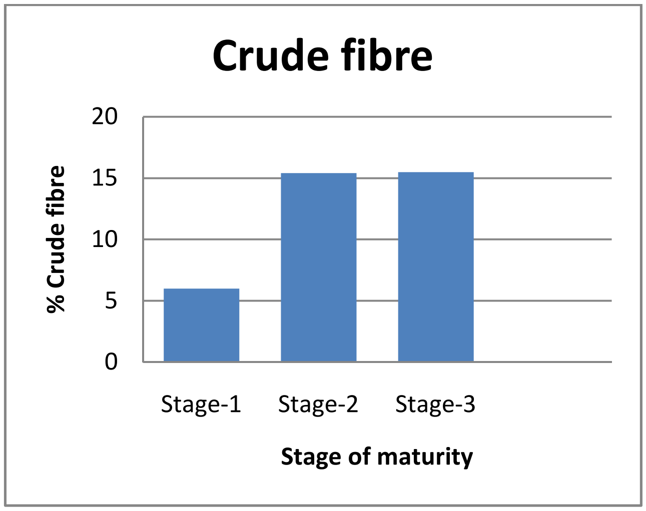

Fig 4.3 % Crude fibre – Stage of maturity

In case of Calcium, there is a decreasing trend with maturation and this may be due to the fact that with increase in maturity, the Calcium content in Cell walls are broken down by the enzymes. The percentage of Ca in fig fruit is relatively small as compared to the other constituents of the fruit, but it is interesting to note that it is higher than that recorded for other fresh fruits.

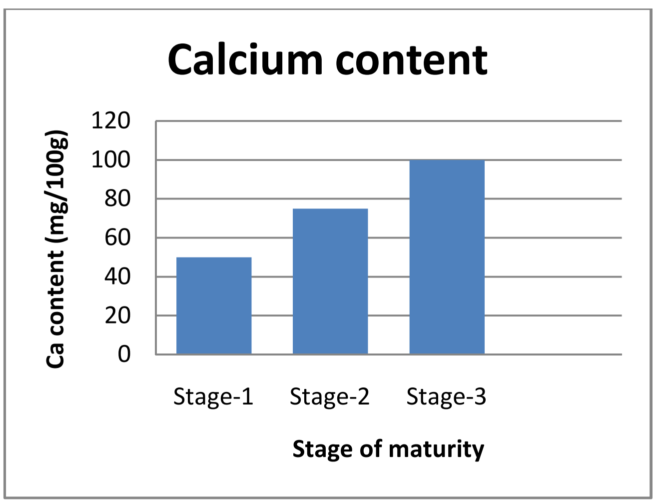

Fig 4.5 Ca content – Stage of maturity

The moisture content in the wild fig decreased with maturity. This was strictly in accordance with the general trend observed in the fruits and vegetables. Studies have shown that, the moisture content in a fruit is inversely proportional to its fat content. This is seen in case of fig fruits in which the fat content is less than 0.3%. Martinez (1995) also reported a similar trend in avocado fruit.

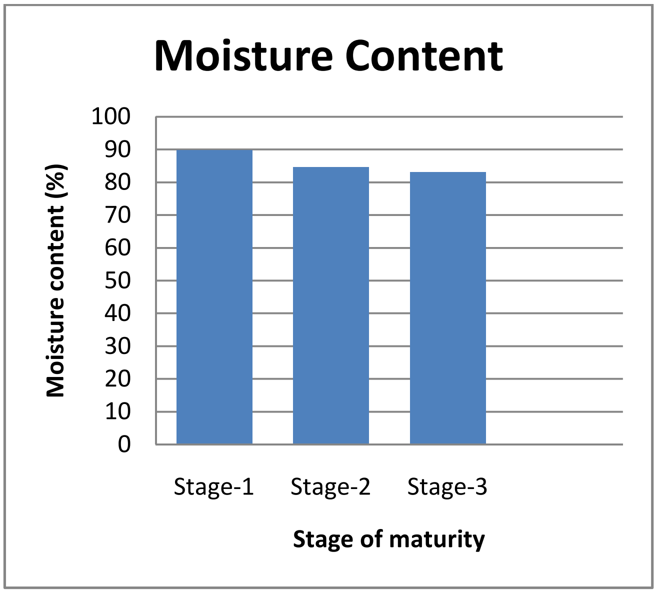

Fig 4.4 Moisture content(%) – Stage of maturity

The colour of the fruit was green in the initial stages, but turned red on maturation. This is because of the degradation of the chlorophyll pigments in the fruit peel. Chlorophyll is broken down and sometimes new pigments are made so that the fruit skin changes color from green to red. This was in correspondence with the observations made by Palmer(1971).

4.3 Development of IMF from fig fruits.

In order to enhance the palatability and taste of this fruit, an IMF product was prepared using sugar and honey as hypertonic solutions. The developed product was compared with fig (*Ficus carica*), which is commercially available in the market. The quality parameters of the sugar based and honey based candies and the commercially available fig were determined and the observation recorded in the Table 4.2.

Si No	Composition	Control	Sugar Based Candies	Honey Based Candies	Commercial dried fig
1.	TSS	7.0	50.0	70.0	72.0
2.	Acidity (%)	0.2235	0.1065	0.165	0.116
3.	Crude fibre (%)	15.5	5.6	8.0	2.8
4.	Calcium (mg/100g)	50.0	48.8	49.1	45.0
5.	Moisture content(%)	87.1	17.0	7.8	3.32
6.	Colour	Red	Light pink	Dark Brown	Light brown

Table 4.2 Composition of Sugar based, honey based and commercially available fig candies

From the table given above, there is not much change in the level of Ca, in different product, but there is a drastic change in the value in case of crude fibre, both in sugar and honey based candies, which may be due to the fact that during the ripening process these substances are gradually broken down by enzymes to more soluble compounds to render the fruit more tender and soft. The moisture content of the processed products were lower than that of the fresh sample. This was achieved by the technique of osmotic dehydration followed by secondary drying. This may enhance the shelf life of the product, improving the quality. Even though The experiment was conducted on 50^{o}B and 60^{O}Brix products, and the quality parameters were more or less the same.

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Plate 4.1 Osmotically Dehydrated Oven Dried 50^{o}Brix

Plate 4.2 Osmotically Dehydrated Oven Dried 60^{o}Brix

Plate 4.3Commercially available fig

Plate 4.4 Honey based fig

4.4 Sensory Evaluation of Value Added Products from Wild Fig

The sensory quality greatly influences the market performance of the product. The sensory quality was assessed for two different products prepared from the wild fig and the sample procured from the market, by a panel comprising 5 members on a 9-point Hedonic scale.It was then compared with the fresh fruit(control). The panelists evaluated parameters such as colour, flavor, taste, texture and the overall acceptability. A numerical scale is given for each attribute and the response of each judge is recorded. Samples are identified with a code number selected at random.

It was seen from the scorecard that the honey based candy had better acceptability, based on the sensory attributes, when compared to the sugar based candies. The product could be safely stored for atleast 3months in polythene.

Table 4.3 Sensory evaluation of IMF products of wild fig

	ATTRIBUTES	COLOUR	FLAVOUR	TASTE	TEXTURE	OA
1.	S-1	2.80	2.60	2.60	2.60	2.65
2.	S-2	3.40	3.20	3.20	2.80	3.15
3.	S-3	2.60	2.40	2.00	2.20	2.30
4.	CONTROL	2.80	2.80	2.80	2.60	2.75

SUMMARY AND CONCLUSIO

CHAPTER 5
SUMMARY AND CONCLUSION

The terms ripeness and maturity, when applied to fruit and vegetables, are often difficult to define. They relate to the time at which the commodity is in the appropriate state for harvesting and for eating. Although the extremes of under-ripeness and over-ripeness are fairly easily defined, exactly when the ripe state is achieved between these two extremes is to some extent subjective and, in the case of a fruit like the tomato, may depend on the degree of sweetness or acidity an individual may find attractive. In fruit during ripening there is a well coordinated series of changes in the composition of the fruit which lead from the unripe to the ripe condition and which give obvious changes in colour, texture, taste and aroma which are readily perceived by the senses.

To get an idea about the change in compositional values with maturation, a study was undertaken to analyse the quality parameters of this fruit at three different maturity stages(30, 60 and 90 days). Wild fig (*Ficus auriculata*) being an under-appreciated resource which could benefit from better utilisation and exploitation by man. The low accepatance of the fruit was mainly due to its low TSS. Therefore, the technique of osmotic dehydration in a hypertonic solution, like sugar and honey, followed by secondary drying in Cabinet dryer was adopted to improve its acceptability and enhance its palatability. However, in the low-income countries, poor care and handling of these crops frequently results in loss of quality, especially when not consumed immediately.

Osmotic dehydration is a useful technique for the concentration of fruit and vegetables, realised by placing the solid food, whole or in pieces, in sugars or salts aqueous solutions of high osmotic pressure. It gives rise to at least two major simultaneous counter-current flows: a significant water flow out of the food into the solution and a transfer of solute from the solution into the food. The effects of osmotic dehydration as a pre-treatment are mainly related to the improvement of some nutritional, organoleptic and functional properties of the product.

In the light of the above literature, the results obtained in the present study as summarised below:

1. The effect of the physico-chemical composition of with different stages of maturity were studied and it was noted that the TSS and the fibre content increased with maturation , while the calcium content and the moisture content decreased. The colour of the fruit changed from green, yellow to red colour with maturation.
2. In order to enhance the palatability and acceptability, IMF products were developed by adopting the osmotic dehydration technique using sugar syrup (50 and 60^{o}Brix) and honey as the hypertonic solution.

3. To enhance the shelf life a secondary drying using a cabinet dryer was employed. In order to bring the product to a safe moisture content of 17%(w.b), the sugar based product was dried for 24 hours at 60 ±1^{o}C, whereas the honey based product took 48 hours under same conditions.
4. The quality of the IMF product was assessed in terms of TSS, Acidity, Moisture content, Ca content , Crude fibre content and the colour.
5. A 9 point Hedonic scale was used for the sensory evaluation of the IMF PRODUCT () and it was compared with the commercially available fig product. It was noted that the honey based ranked superior in all aspect followed by 50^{o}Brix sugar candy.

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DEVELOPMENT OF INTERMEDIATE MOISTURE PRODUCT FROM WILD FIG (*Ficus auriculata*)

Lakshmi,E.Jayachandran

Neethish Varghese

ABSTRACT OF THE PROJECT

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Department of Post Harvest Technology and Agricultural Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679573, MALAPPURAM

KERALA, INDIA

ABSTRACT

Wild fig (Ficus auriculata) fruits are highly nutritious, yet an under-utilised fruit was highly perishable in nature .A study was undertaken to analyse the quality parameters of the fresh fruit, at three different stages of maturity (30, 60 and 90 days). Even though it is nutritious, because of its low TSS content, it is not a widely accepted fruit. In order to enhance the acceptability and palatability , this study aims to develop an IMF product , by adopting the osmotic dehydration technique, using sugar and honey as hypertonic solution followed by a secondary drying using cabinet dryer. The study concluded that the honey based candies followed by 50 degree Brix sugar based candies were of acceptable sensory and physico-chemical quality and it is comparable with the commercially available dried fig (*Ficus carica*).

APPENDIX

APPENDIX 1

1. Preparation of the ash sample

Well accurately a suitable quantity of the well mixed sample in a tared silica dish (Sample used for the determination of moisture content may be taken for ashing).Heat first over a low Bunsen flame to volatilize as much of the organic matter (until no more of smoke is given out by the material) as possible. Transfer the dish to a temperature controlled muffle furnace. Keep the muffle at about 300^0C until all the carbon has ceased to glow and then raise the temperature to 420^0C. The time required at this temperature will depend on the nature of material to be ashed. Generally, 5-7 h are sufficient to ash most of the fruits and vegetables or their products. Remove from the muffle furnace, allow to cool and if required, note the weight of the ash. Cover the dish with a watch glass and add gently 40 – 50 ml of dil.HCl with the help of a pipette. The watch glass is used to prevent spattering. Heat over a water bath for 30 min, remove the cover and rinse. Continue heating for another 30 mins to dehydrate silica. Add another 10 ml of HCl and add water to dissolve soluble salts. Filter into a 100 ml volumetric flask using Whatman Filter paper. Wash the residue in the basin once / twice using dilute HCl. Make up to the volume with water. Return the filter paper to the dish, ignite, place in muffle furnace for 1h at 450^0C.

APPENDIX 2

1. Preparation of 4 % Ammonium oxalate.

Dissolve 4 g ammonium oxalate in 100 ml of distilled water

2. 0.01 N Potassium permanganate

Dissolve 316 mg $KMnO_4$ in 100 ml of distilled water

3.2N H_2SO_4

Dilute 56 ml of conc. H_2SO_4 to `100 ml using distilled water

4.0.255 N H_2SO_4

Mix 6.79 ml H_2SO_4 in water and make upto 1l(1.25%).

5.0.313N NaOH

Dissolve 12.5 g NaOH in water and make upto 1L(1.25%).

6. Preparation of 0.1 N NaOH

Weigh 0.1 g of NaOH pellets and dissolve it in 100 ml f water.

APPENDIX 3

Scorecard for sensory evaluation

ACCEPTABILITY TEST

Scorecard Hedonic Scale

Judge Name: ______________________ Date ______________

Product Name ___________________________

Attribute: ____________________

Degree of Preference	Sample #	Sample #
Like very much		
Like much		
Like moderately		
Slightly like		
Neither like nor dislike		
Slightly dislike		
Dislike moderately		
Dislike much		
Dislike very much		

Comments: ____