FORMULATION AND EVALUATION OF NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

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A DISSERTATION SUBMITTED TO THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN (DEEMED UNIVERSITY) COIMBATORE - 641 043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

MASTER OF PHILOSOPHY IN FOOD SCIENCE AND NUTRITION

JUNE 2004

CERTIFICATE

This is to certify that the dissertation entitled **"FORMULATION AND EVALUATION OF NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS"**, submitted to the Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, in partial fulfilment of the requirements for the award of the Degree of **Master of Philosophy in Food Science and Nutrition** is a record of original research work done by **Miss. T. PADMA PRIYA** during the period of her study in the Department of Food Science and Nutrition , Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore under my supervision and guidance and the dissertation has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship or other similar title to any candidate of any other University.

Signature of the Guide

Signature of the Head of the Department

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

The investigator expresses her heartfelt gratitude to ***God Almighty,*** *whose blessings guided her in carrying out the research successfully.*

The investigator owes her reverential gratitude to ***Late Hon. Colonel Tmt. Rajammal P. Devadas, M.A., M.Sc., Ph.D., (Ohio State), D.Sc (Madras), Hon.D.H.L. (Oregon), Hon.D.Sc. (C.Azad, Agri, Kanpur), Hon.D.H.L. (Ohio State),*** *Former Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women - Deemed University, Coimbatore for her continuous blessings.*

With deep respect and reverential gratitude the investigator wishes to thank ***Thiru. K. Kulandaivel, M.A. (Ohio State), Ph.D. (Madras),*** *Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for providing the opportunity to conduct the investigation in our esteemed University.*

The investigator records her sincere thanks to ***Tmt. Chandramani, M.Sc., (Baroda), M.Ed., Ph.D (Madras),*** *Vice Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for providing all the amenities required for the conduct of the study.*

The investigator expresses her sincere thanks to ***Tmt. Saroja Prabhakaran, M.A.,Dip.Ed. (Madras), Ph.D. (Mother Teresa),*** *Registrar, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for providing the necessary infra structural facilities.*

*The investigator records her gratitude to **Tmt. N. Jaya, M.Sc., Ph.D (Madras)**, Dean, Faculty of Home Science, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for her constant encouragement in conducting the research.*

*The investigator owes her heartfelt thanks and deep sense of gratitude to **Tmt. S.Premakumari, M.Sc., M.Phil, Dip.Ed., Ph.D., (Madras)**, Professor and Head, Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, for her consistent encouragement and valuable advice throughout the conduct of the study.*

*Words are compendious to express the investigator's gratitude to **Tmt. U.K.Lakshmi M.Sc., M.Phil, Dip.Ed., (Madras), Ph.D., (Avinashilingam)**, Reader , Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore for her valuable guidance, amicable suggestions, constant encouragement, untiring enthusiasm, meticulous efforts and generous assistance for the successful execution of the study.*

The investigator places her heartfelt gratitude to her beloved parents, brother and dearest friends for their moral support and constant encouragement throughout the course of the study.

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INTRODUCTION

INTRODUCTION

Nutritional adequacy is one of the key determinants of the quality of human resources everywhere. The problem of malnutrition in developing countries encompasses a spectrum of deficiencies of which the most alarming is the deficiency of micronutrients.

Micronutrient malnutrition such as iron, iodine and vitamin A deficiencies are widely prevalent and thus form the major public health concerns. Micronutrient deficiencies can lead to specific impaired functions of human performance, such as decreased productivity in adults and poor cognitive development in school children.

It is estimated that 41 per cent of the population aged under five in the developing world has an inadequate vitamin A intake resulting in increased morbidity and mortality. Half a million children go blind each year as a result of vitamin A deficiency. Thirteen and a half million have night blindness, the first sign of vitamin A deficiency (Duncan, et al., 2000).

In India over 80 per cent of the pregnant women and over 50 per cent of pre school children and adolescent girls are reported to be anaemic (Vir, 1998). It was estimated that about 90,000 still births and neonatal deaths occur every year due to maternal iodine deficiency. Around 40 million persons have goitre (NIN, 1998). Studies conducted by Rao et.al., (2002), showed that the overall prevalence of goitre to be 30 per cent in India.

About 183 million children globally are malnourished, weighing less than their ideal body weights. Approximately 30 per cent of all new borns begin their life with a disadvantage of birth weights less than 2.5 kg which is a significant underlying cause of death in new borns and infants. A majority of children i.e. 68.6 per cent between 1-5 years are underweight, 65.1 per cent are stunted and 19.9 per cent wasted (UNICEF, 1999).

Lack of proper feeding practices, poverty, ignorance, food fads and delayed supplementation are pertinent predisposing factors for the etiology of rampant malnutrition among young children in India. Economically affluent people meet the nutritional requirement of their children by feeding commercial weaning foods, but this is beyond the reach of the poor socio-economic group. There is, hence, an urgent need to develop low cost nutritious supplements, using the judicious combinations of less expensive cereal, pulses, groundnut and jaggery available in rural households.

"Kuzhandai Amudu" - a nutritious food developed by Devadas et al., (1974) provides 13.1g of protein and 387 kcals per 100g and this fulfils one third of the daily nutritional requirements of a child under five years. Like this several diet combinations based on local dietary patterns were developed to combat protein energy malnutrition. But there is no relevant data on development of nutritious mixes incorporated with fruits to combat vitamin deficiencies. Hence there is an urgent need to develop low cost nutritious supplements using the judicious combinations of less expensive foods incorporated with fruits.

India stands second in fruits and vegetable production by producing about 86 and 43 million tonnes respectively (Government of India, 2000). India with its diverse, but favourable agroclimatic conditions produces a wide range of tropical and temperate fruits and vegetables. The area of fruits cultivation increased from 1.22 million hectares to 3.35 million hectares in 1995-96. India with a production of 41.50 million tonnes (1996-97) is the second largest producer (next to China 45-46 million tonnes) with a share of eight per cent in world fruit production (Chadha, 1995).

Almost all the states of India have fruits orchard. Many types of tropical, semi tropical and temperate fruits are cultivated. Glucose, fructose, sucrose and starches constitute the "available carbohydrates" of fruits and the caloric value of the fruit depends to a large measure on the concentration of these components.

In terms of nutrition, fruits are very good sources of several vitamins, mineral salts and dietary fibre, all of which are essential for good health. Fruits like lemon, guava, watermelon and sapota provide significant amounts of iron and other trace minerals.

Papaya (carica papaya) known as the wonder fruit of the tropics can provide the essential protective nutrition for the poorest section of the society. Papaya is nutritious and has much therapeutic value (Directorate of Extension, 2000). Papaya is unique among the fruit crops because of its high yielding potential and year round fruiting behaviour (Singh et al.,1998).

Papaya is a best source of antioxidants such as beta-carotene and vitamin C (Salunkhe and Kadam, 1995) whose role in human health are well established.

Among the numerous seasonal fruits available in India, sapota enjoys immense popularity in the coastal areas (NIN, 2001). The fruits are available in plenty when other common fruits go out of market. The sapota/ chikku is a good source of energy since almost 14 per cent of its pulp is sugar. The fruit also has some amount of iron, beta carotene and vitamin C. The ripe fruits are pleasantly flavoured, rich in sugar i.e 12-14 per cent and also a rich source of minerals (Sulladmath and Reddy, 1985).

Sapota is a delicious fruit valued for its mellow and sweet pulp. The matured fruits are used for making mixed fruit jams and they provide valuable source of raw materials for the manufacture of industrial glucose, pectin and natural fruit juices.

Ripe sapota fruits are highly perishable in nature and cannot be stored for more than 2-3 days. Hence the post harvest losses are enormous. These losses are high in tropical country like India and range between 25-30 per cent (Salunkhe and Desai, 1984).

Though India is world's second largest producer of fruits and vegetables, hardly five per cent of the produce is processed and 30 per cent of the annual produce is wasted due to lack of preservation facilities (India budget, 2001).

A need therefore prevails to develop suitable technology for processing of fruits which will not only check the loss of fruits but also retain nutritional quality in the processed product. One such technology is the conversion of the fruit into free flowing powder by removing its moisture (Mishra et al., 2002).

Food preservation by drying is one of the methods practiced from ancient times. The best and most inexpensive method to make the fruits available through all seasons is drying. It is an important food processing technique because not only does it preserve the harvest for future use, but it can also increase the food's nutritional density and nutrient availability, increasing its value as an ingredient in weaning foods (Cleveland and Soleri, 1991).

The principle of drying is to use heat to supply energy which removes the water from the food. By this process the equilibrium, Relative Humidity (RH) of the food is decreased to a low enough value to prevent microbial growth and chemical reactions. In drying, a food loses its moisture content, which results in increasing the concentration of nutrients in the remaining mass.

Dried fruits are unique, tasty sometimes even tastier than fresh fruits and nutritious and are called as nature's candy. Dried fruits taste sweeter because the water has been removed thereby concentrating sweetness and flavour (Reynolds, 1993). Some of the dehydrated tropical fruits are rich in minerals like calcium, phosphorus and very rich in sugars. Beta carotene is fairly stable.

Dehydrated fruit based mix can provide adequate amount of vitamins and minerals if combined with other less expensive foods like wheat/ ragi, roasted bengal gram / green gram, jaggery and groundnut. So development of ready to eat nutritious mixes at low cost with extended shelf life assumes significance in Indian content with twin objectives of preservation and prevention of malnutrition, vitamin A and iron deficiencies.

Since not much data are available on the development and evaluation of nutritious mixes incorporated with papaya and sapota powders, the present study has been undertaken with the following specific objectives to:

- Identify the suitable method for dehydration of papaya and sapota
- Evaluate the nutritive value of the dried fruit powders
- Develop nutritious mixes incorporated with papaya and sapota powders
- Conduct acceptability trials for all the developed mixes
- Evaluate the nutritive value of the highly accepted nutritious mixes and
- Study the shelf life of the highly accepted nutritious mixes.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The literature pertaining to the study entitled "Formulation and Evaluation of Nutritious mixes Incorporated with Papaya and Sapota Powders" is discussed under the following headings:

A. Significance of Fruits in Dietaries with Special Reference to Papaya and Sapota

B. Importance of Formulating Nutritious Mixes to Tackle Nutrient Deficiencies

C. Need for Incorporating Papaya and Sapota Powders in Nutritious Mixes

A. SIGNIFICANCE OF FRUITS IN DIETARIES WITH SPECIAL REFERENCE TO PAPAYA AND SAPOTA

Today India is the second largest producer of fruits in the world with 44 million tonnes of production (Indian Horticulture Database, 2000). Our share in the world production of fruits is about 10 per cent. According to Srivastava and Kumar (2002), horicultural crops contribute about 20 per cent of the gross agricultural output in the country.

Williams et.al., (1999) remark that fruits and vegetables are the "natural mix" of the chemicals that elicit protection, which is more important than any nutrient that can be added to the diet.

Fruits and vegetables, which are among the perishable commodities, are important ingredients in human dietaries. Due to their high nutritive value, they make significant nutritional contribution to human well-being. They can be supplied in fresh or preserved form throughout the year for human consumption (Srivastava and Kumar, 2002).

Vegetables and fruits constitute important items of human diet and they form a major source of several antioxidants required by the body (Raghuram, 2000).

Fruits, as dependable sources of vitamins, exert a tonic effect in the body. Guava, custard apple and citrus fruits like lemons and oranges are particularly valuable sources of vitamin C. Several fruits contain good amounts of carotene which gets converted to vitamin A in the body. Papaya is an excellent source of vitamin C and carotene (Singh et al., 1998).

Diets containing ample plant foods such as fruits, vegetables, herbs and grains are low in total and saturated fat and high in fibre and protective compounds (Haddad et.al., 2000).

Numerous ecological studies, prospective studies and controlled studies showed an association between fruits and vegetables intake and decreased risk of cardiovascular diseases (Appel et.al., 2000).

Brouwer et.al., (1999), reported that increasing dietary intake of vegetables and citrus fruits, both good sources of folate improve folate status and decrease plasma total homocysteine levels which may help to prevent cardiovascular diseases.

Thompson et.al., (1998), reported that consumption of a diet with increased vegetables and fruit intake resulted in significant reduction in oxidative cellular damage.

Bravo (1998) states that higher fruits and vegetable intake lower the risk of cancer development. Evidence suggests that increased consumption of fruits and vegetables lower risk for many cancers especially epithelial cancer of the alimentary and respiratory tract. (Steinmetz and Potter, 1996). According to Ziegler et.al., (1997), individuals who eat more fruits and vegetables, which are rich in carotenoids, and people who have high serum beta carotene levels have a lower risk of cancer.

World Health Organization study group (WHO, 1990) reported that a diet low in total and saturated fat and high in plant foods (green, yellow vegetables and fruits) was consistent with a low risk of cancers of colon, prostate, breast, stomach, lung and esophagus.

High intake of fruits and vegetables may influence glucose metabolism and the increased consumption may contribute to the prevention of diabetes (Sargeant et.al., 2001).

According to Raymond (2000), foods such as fruits and vegetables are basic to healthful low fat diet. Low fat diet contains a high proportion of complex carbohydrates, fruits and vegetables. They are naturally high in fibre and low in calorie density. Individuals consuming these type of diets derive fewer calories and lose weight (Pritikin, 2000). The relatively low fat and energy contents of most vegetables and fruits may reduce the risk of obesity (Kristi et.al., 1996).

According to Gala et.al., (2000), those who want to lose weight should make a liberal use of cucumber. Grapes are helpful in eliminating thirst burning sensations, tuberculosis, obesity and other disorders. One or two ripe tomatoes taken early in the morning with breakfast for a couple of month is considered to be a safe method of reducing weight (Bhakru, 1999).

Law and Morris (1998), state that fruits and vegetables intake reduce the risk through the beneficial combination of micronutrients and antioxidants in them. Charleux (1996), points out that the beneficial effects of fruits and vegetables could be related to beta carotene, vitamin C, vitamin E which are thought to act mainly as antioxidants. Singh (2001), indicates that fruits and vegetables high in vitamin C are associated with a reduced risk of death from all causes including heart diseases.

According to Gopalan and Mohanaram (2000), fruits and vegetables are good sources of dietary fibre, which is essential for good health. Brown et. al., (1999), implies that fibre can be found in fresh fruits and vegetables, whole grain cereals and dried beans (Shanmuganathan, 2000). It reduces the amount of fat and cholesterol.

Salmon et.al., (1997), point out that cereal fibre was inversely associated with diabetes risk whereas fibre from fruits and vegetables was unrelated to diabetes risk.

In addition, fruits are good sources of cellulose which help in intestinal activity and thereby prevent chronic constipation (Ram, 1990). Fruits are highly beneficial in maintaining acid-base balance in the body. According to Bakhru (1999) fruits neutralise the toxicity resulting from excessive intake of acid-forming foods and restore alkalinity. They help to clear the system of morbid waste and cater to the body's requirement of natural sugar, vitamins and minerals. Clinical observations as reported by Singh et.al., (1989), have shown that potassium, magnesium and sodium present in fruits act as diuretics. They lower the urine density and thereby accelerate the elimination of nitrogenous wastes and chlorides.

Bhakru (2001), says that there are certain substances in fruits and vegetables which have mysterious power to reduce blood pressure and he considered fibre to be one of such substances, especially in fruits.

(1) Importance of Papaya

India's papaya production accounts for about 7 per cent of world's production. In Asis, papaya accounts for less than one per cent of the total fruits produced (FAO, 1991). Papaya is a tropical fruit and grows well in all soils except in rocky areas. India's climatic conditions are suitable for the growth of papaya.

Papaya is a very popular fruit due to its taste and being rich in nutrients and digestive enzymes. It is also a remunerative fruit crop in India (Singh et.al., 1998). Rhodie and Imperio (1993) regarded papaya as one of the most useful and nutritious fruit of the tropics having three general uses such as being a sweet fruit, a vegetable and a source of medicine.

Papaya is quite nutritious and has much therapeutic values. Though there are a large number of papaya varieties, the characteristics of these different varieties vary under different conditions. In papaya the sugar content is greater than the acidity and therefore the sweetness predominates (Reni et.al., 2000).

Papaya is a best source of antioxidants such as beta-carotene and vitamin C (Salunkhe, 1995), whose role in human health are well established. Hundred grams of edible portion contains 880 μg of beta-carotene and 51 mg of vitamin C, which increases with maturity of the fruit (Murali, 1991).

Papaya is a rich source of carotene, vitamin C besides minerals (Aruna et al., 1989). Papaya, mostly used as a table fruit is considered nutritious due to substantial presence of total carotene in general and beta carotene in particular (Food Digest, 2002).

Sundararaman (1992) lists the five soluble enzymes present in papaya fruits namely, a proteolytic ferment which decomposes proteins, a coagulating ferment which acts upon milk casein, a ferment which has the power to attack starch, a clotting ferment similar to pectose and a ferment possessing the power to act on fats.

The ripe papaya is delicious, heavy, warm, oily, laxative and antibilious. It increases virility. It is beneficial to the heart and liver. It helps to alleviate insanity and checks splenic enlargement (Splenomegaly). It is a good medicine for constipation and urinary disorders (Joseph, 2002).

According to Bakhru (1999) unripe papaya helps in the contraction of the uterine muscles and is thus beneficial in securing proper menstrual flow. Papaya is an excellent tonic for growing children, pregnant women and nursing mothers.

Chadha (1992) reported that the use pattern of papaya as fresh as well as processed product has shown an upward trend.

(2) Importance of Sapota

Sapota is one of the prominent fruit, acquiring a number of names like chiku, ellupai, dilly, naseberry, saprotille and sapodilla plum (Shinde, 1993). The ripe fruit is a perishable commodity with a shelf life of 2-3 days. The pulp of ripe fruit is sweet and has a pleasant flavour with high nutritive value.

Sapota is a delicious fruit valued for its mellow and sweet pulp. The fruit is a good source of sugars, which range from 12 to 18 per cent. The matured fruits are used for making mixed jams and they provide valuable source of raw material for the manufacture of industrial glucose, pectin and or natural fruit juices.

Sapota is a good source of energy since almost 14 per cent of its pulp is sugar. The fruit also has some amount of iron (2.0 mg %) carotene (97 μg) and vitamin C (6mg). Sapota is an easily available low cost fruit with a delicious honey like flavour relished by one and all (NIN, 2001).

B. IMPORTANCE OF FORMULATING NUTRITIOUS MIXES TO TACKLE NUTRIENT DEFICIENCIES

Life cannot be sustained without adequate nourishment. We need adequate food for growth, development and to lead an active and healthy life. Both plant and animal food sources need to be improved to meet the nutritional requirements of the growing population (Gopalan et al., 1995).

The lack of required amount of nutrient at the crucial stage in the development of an individual results in malnutrition leading to stunted physical and mental growth. Malnutrition is a pathological condition arising from coincident lack, involving in varying proportions of protein and calories occurring most frequently in infants and young children and commonly associated with infection. Under nutrition, protein calorie malnutrition, vitamin A deficiency, iron deficiency and calcium deficiency are prevalent among infants. (WHO, 1998).

In India, one third of children below five years of age, are moderately to severely malnourished and approximately 6000 to 7000 children die everyday of malnutrition (Devi and Geervani, 2000). Malnutrition especially micronutrient malnutrition such as iron, iodine and vitamin A deficiencies are widely prevalent and thus require major public health concerns. Micronutrient deficiencies can lead to specific impaired functions of human performance, such as decreased productivity in adults and poor cognitive development in school children (Francis, 1995).

Protein - energy malnutrition leads to various degrees of growth retardation. When growth retardation is severe, functional deficiencies, like resistance to infection and poor intellectual development may result (NIN, 1998).

Rao et.al., (2002), stated that if supplements are not introduced in the early age, young children are likely to endup with gross malnutrition in the later childhood. According to Udani (1990) the quality and quantity of the supplement provided at the weaning age determines the nutritional status of the children.

Young (1993) reported that cereals are usually the first solid food given to infants, because they are readily available and culturally acceptable staple foods.

Development of weaning foods and supplementary foods based on cheap, locally available foodstuffs which are familiar to rural mothers has been one of the strategies suggested by Devadas et al., (1984), to combat protein energy malnutrition. Nutritious weaning foods help to bridge the gap of calories which is mainly responsible for malnutrition in weaned infants, especially children from poor communities (NIN, 1993).

The complementary approaches to the problem of malnutrition are to ensure that breast feeding is continued throughout the first year of life and to ensure that supplementary foods are available and used to complement breast milk as the child's nutritional requirements increase beyond the age of four to five months, which cannot be met by breast milk alone (Desikachar, 1980; Devadas et al., 1983; Mohanram, 1983; Hofvander and Underwood, 1985; Malleshi, 1988; Gopaldas, et al., 1991).

In the absence of appropriate supplementary foods frequency and severity of health problems rise sharply. Deaths during the period of weaning were 10-15 times higher in India than in industralized countries. Experiences have shown that better infant feeding practices can make an important contribution to the reduction of Infant Mortality Rate (Khanna, 1983). In developing countries like India poverty and low purchasing power are no doubt the major factors contributing to malnutrition (Mohanram, 1983).

Rao (1983) suggested the initiation of supplementary feeding for the breast fed infants belonging to poor-socio economic groups around the age of six months.

Lambert and Hall (1996), recommended to start weaning the infants at four months of age since delayed weaning can lead to feeding problems. According to him breast fed infants need vitamin D and possibly iron supplements after 4 months. Vitamin C is also needed to enhance iron absorption.

Several low cost indigenous diet combinations are generated to suit the local food habits and pattern using ragi, wheat, greengram, bengal gram, ground nut and rice as the staple low cost indigenous foods. Cereals along with pulses form a major bulk of dietary protein, calories, vitamins and minerals to the world population in general and to the developing world in particular. Since cereals/millets are the cheapest widely available source of energy, their contribution to energy intake is the highest among the poor income families and it decreases with increasing income (Gopalan, 1996).

The adoption of traditional methods of processing food to overcome malnutrition in developing countries has been a great concern to many food scientists and nutritionists during this decade. The world food and nutrition study on higher quality in local methods of food processing and preparation give emphasis to increased research into traditional food processing methods suitable for developing countries.

Such an approach is necessary due to the decreasing power of most of the people as a result of poor economic conditions and the nutritional needs of the ever increasing human population in these countries (Mtebe et al., 1993).

C. NEED FOR INCORPORATING PAPAYA AND SAPOTA POWDERS

The long term strategy to combat micronutrient malnutrition on a sustainable basis necessarily have to be food based encouraging the use of science and technology to produce stable products from perishable local plant foods. The challenge before us is to explore these plant foods, increase their production and availability, prevent their wastage through simple methods of preservation and storage, improve culinary practices to avoid micronutrient loss during cooking and develop appropriate methods of processing these foods to enhance their nutritive value, acceptability and shelf life (Gopalan, 1996).

The most logical way of combating vitamin A deficiency would be to improve the nutritional status of women during pregnancy and ensure the intake of green leafy vegetables and fruits in the diets of infants from the age of six months (NNMB, 2000).

India's total annual fruit and vegetable production is about 131 million tonnes during 1998-99. Today, India is the second largest producer of fruits (44 million tonnes) and vegetables (87.5 million tonnes) (Srivastava and Kumar, 2002 and Government of India, 2000).

However, for various reasons, this abundance of production is not fully utilized and about 20-30 per cent of it is wasted due to spillage. Most of the fruits and vegetables are seasonal crops and are perishable in nature (Srivastava and Kumar, 2002 and India budget, 2001)

In a good season, there may be a local glut of fruits and the surplus cannot be taken quickly enough to the markets in urban areas because of inadequate transport, road and packaging facilities. The surplus often cannot be stored for sale in the off-season because of inadequate local cold storage facilities. Due to all these reasons there is a tremendous loss to the cultivators (Thangam Philip, 1998).

There has been substantial increase in production and productivity of papaya owing to development of high yielding cultivars and production technology. India is a major producer of papaya next to Brazil and Indonesia. It produces nearly 2,72,000 metric tonnes of papaya every year (Choudhary, 1995).

Papaya is a delicate fruit, highly perishable when ripe. The postharvest losses of fresh papaya vary from 40-100 per cent in different countries with varying climatic conditions. Hence preservation of this fruit without loss of quality for extended periods needs immediate attention (Chadha, 1995).

Ripe sapota fruits are pleasantly flavoured and rich in sugar i.e. 12-14 per cent and also rich in minerals (Sulladmath and Reddy, 1985). The ripe fruits are perishable in nature and cannot be stored for a long period, hence the post harvest losses are enormous. These losses are high in tropical country like India and range between 25-30 per cent (Salunkhe and Desai, 1984).

A need therefore prevails to develop suitable technology for processing which will not only check the loss of fruits but also retain nutritional quality in the processed product. One such technology is the conversion of the fruit into free flowing powder by removing its moisture and preservation coupled with economy of packaging, transportation and storage (Mishra, et al., 2002).

The important food preservation techniques are dehydration, canning, fermentation, radiation, freezing, use of chemical preservatives, addition of sugar, salt etc. Of these, dehydration which is an ancient art of processing fruits and vegetables is one of the most widely accepted methods on a commercial scale. Sundrying has been used for drying agricultural products from time immemorial (Shakunthalamanay and Shadaksharaswamy, 1996).

According to CFTRI (1990), papaya slabs could be prepared by dehydrating the pulp after the addition of sugar (1.5 per cent), citric acid (0.5 per cent) and potassium meta bi sulphite (0.3 per cent) and spread on greased aluminium or stainless steel trays in layers of one cm thickness and dried in a cabinet drier at 50 - 60°C . The dried product could be stored well for about eight months at 24 - 30°C although losses of some of the nutrients were considerable.

Dried fruits can be eaten as a snack or added to cereals, muffins or ice creams for diabetics or dieters, dried fruits satisfy that craving for sweets but they should consume only the amount equal to the fresh fruit exchange since drying removes water and not the calories (Reynolds, 1993).

Drying is an important food processing technique because not only does it preserve the harvest for future use, but it can also increase the foods nutritional density and nutrient availability, increasing its value as an ingredient in weaning foods (Cleveland and Soleri, 1991).

Moy and Kho (1988) designed a solar osmotic drier to test the utilisation of solar energy in the two step osmo vac dehydration of papaya which suggested the possibility of increased drying rate and quality retention.

Swaminathan (1988) recommends that preservation methods should be selected in such a way that the nutritional value of foods should be unaltered. Carotene losses were quite high (50-70%) during sun drying of fruits. The loss of nutrients depends on the individual processing.

At home scale level, sun drying is a popular technique whereas at commercial or industrial scale many types of mechanical driers are used under controlled conditions of temperature, humidity and airflow. Use of driers results in better colour and more uniform quality. Also, the same nutritive value and palatability standards as fresh foods have been found (Thangam Philip, 1996).

Solar drying to preserve food items like spices, vegetables, fruits, meat, rice and fish, is practised for centuries. Under industrialised conditions the processing of cereal based weaning foods usually undergoes some kind of procedure like enzyme treatment, pressure extrusion cooking etc to reduce the dietary bulk, which makes it possible to cover energy and other nutrient requirements during the weaning period (Rossen and Miller, 1973). However, they are technically sophisticated and not suitable in small scale processing at village level. So research in India has attempted to overcome this issue by giving much importance to home based technologies which are simple to carry out even at village levels, thus reducing the bulk and increasing the calorie density of weaning foods (Desikachar, 1988, Gopaldas, 1988).

Weaning mix containing cereal (maize, ragi or cholam), pulse (roasted green gram and bengal gram) oil seed (roasted groundnut) and jaggery in the ratio of 3:2:1:2 was developed and named as "Kuzhandai Amudhu" (Devadas et al., 1974).

Aruna et al., (1998), developed cereal based powder using papaya and wheat flour by drying in a hot air oven drier and the product was found to be acceptable and kept well for about six months.

Dhanalakshmi et al (1998) prepared a cereal based dehydrated papaya powder incorporated food and reported that the percentage losses of vitamin C, total carotenes and beta carotene to be 62, 55 and 51 respectively during the nine months storage.

Dehydrated papaya powder incorporated cereal based preparations retained 47 and 49 per cent of total and beta carotene respectively. Non-alcoholic paw paw (papaya) beverage was manufactured by both sun and controlled oven drying. The loss of vitamin A was 97 and 92 per cent (Mugula et al., 1999).

Rao and Thimmayamma (1982) prepared weaning foods which consisted basically of cereal and pulse combination with or without jaggery or sugar and addition of an oil seed such as groundnut or sesame and GLV to improve the quality of the recipe.

Kalsi and Dhawan (2001) developed a guava powder by osmo-air drying technique and showed a significant increase in reducing sugars, moisture, pectin, browning and decrease in ascorbic acid and tannins when stored.

Mahadeviah (1987) prepared papaya cereal flakes by combining 4.5 kg pulse, 4.7 kg wheat flour, 2.6 kg sugar, 2.5 kg glucose, citric acid and pectin. The prepared mass was then dried into flakes in a double drum drier heated by steam pressure at 4.2 kg/m^2 and at 2-3 rpm clearance between the drums. The flakes were superior in colour, texture, taste, aroma and overall acceptability.

Mango powders developed from ripe mango pulp (85 per cent) using milk concentrate (5 per cent) and wheat flour (10 per cent) as additives by vaccum dehydration contained 3.1 to 3.8 mg/100g and 4.65 to 5.8 mg/100g of beta carotene and total carotene respectively. Additionally they are fair sources of protein (10.9 to 12.58 g/100g), fat (3 to 3.5g/100g), vitamin C (52 to 76mg/100g), iron (1.59 to 5.2 mg/100g) and calcium (122 to 145mg/100g) (Food Digest, 2002).

EXPERIMENTAL
PROCEDURE

III EXPERIMENTAL PROCEDURE

The experimental procedure adopted for the present study entitled "Formulation and Evaluation of Nutritious Mixes Incorporated with Papaya and Sapota Powders" is presented under the following headings:

A. Selection of Fruits for the Study

B. Identification of Suitable Method for Dehydration of Papaya and Sapota

C. Analysis of Nutrients and Selection of Suitable Papaya and Sapota Powders for Further Study

D. Formulation and Preparation of Nutritious Mixes Incorporated with Solar Dried Papaya and Sapota Powders.

E. Acceptability Testing of the Developed Nutritious Mixes.

F. Analysis of Nutrients of the Highly Accepted Papaya and Sapota Powder Incorporated Nutritious Mixes

G. Keeping Quality and Cost of the Highly Accepted Nutritious Mixes

A. Selection of Fruits for the Study

Papaya is considered as a fruit of choice of the processing sector, as the availability of the fruit is largely spread throughout the year. The comparatively cheaper cost of papaya, higher recovery of pulp, attractive colour of the flesh and suitability for a wide range of processed products make it more ideal for processing (Durijagtiani, 1995). It is very rich in beta carotene and has an important role in alleviating vitamin A deficiency. Hence for the present study papaya was selected as one of the fruit.

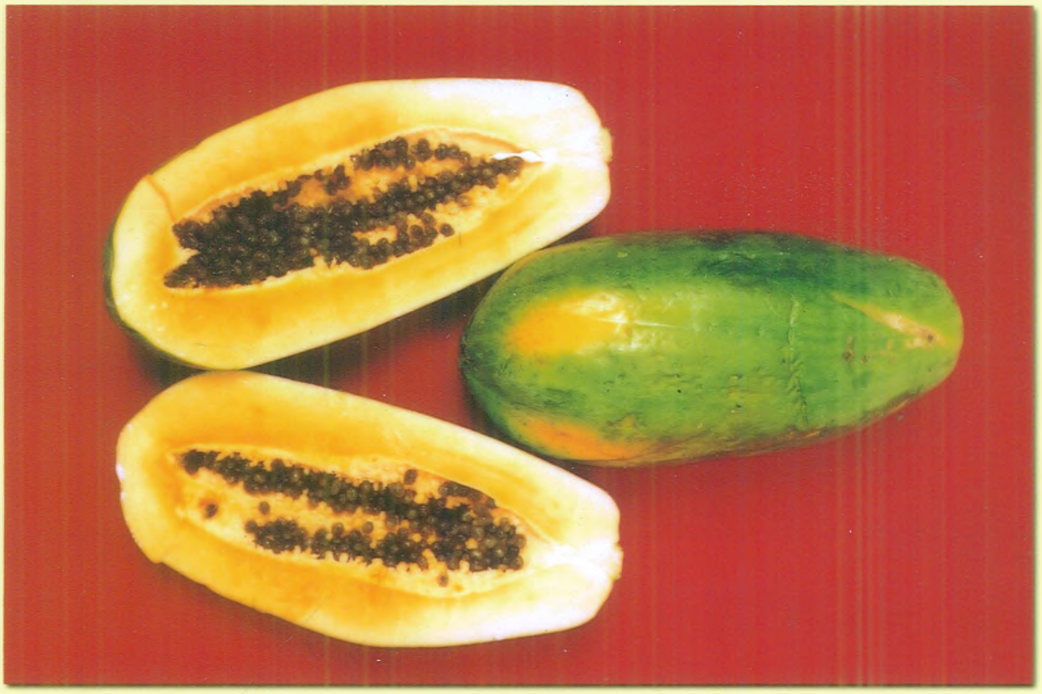
Sapota (Achras Sapota L) is one of the prominent fruit which has acquired a number of names like chikku, ellupai, dilly, naseberry, saprotille, and sapodilla plum (Shinde, 1993). The pulp of ripe fruit is sweet and has a pleasant flavour with high nutritive value. In India, sapota is usually available in plenty when other common fruits go out of market. Taking these factors into consideration sapota was selected as another fruit for the study. Papaya and sapota used for the study are given in Plate 1.

In general, fruits are highly perishable, unless they are processed, preserved and stored in a proper way, the excess production will go as a waste. In this context it is alarming to note that in India nearly 30-40 per cent of the annual produce is wasted due to lack of preservation infrastructure (Adfule, 2002). Hence preservation of fruits without loss of quality for extended period needs immediate attention.

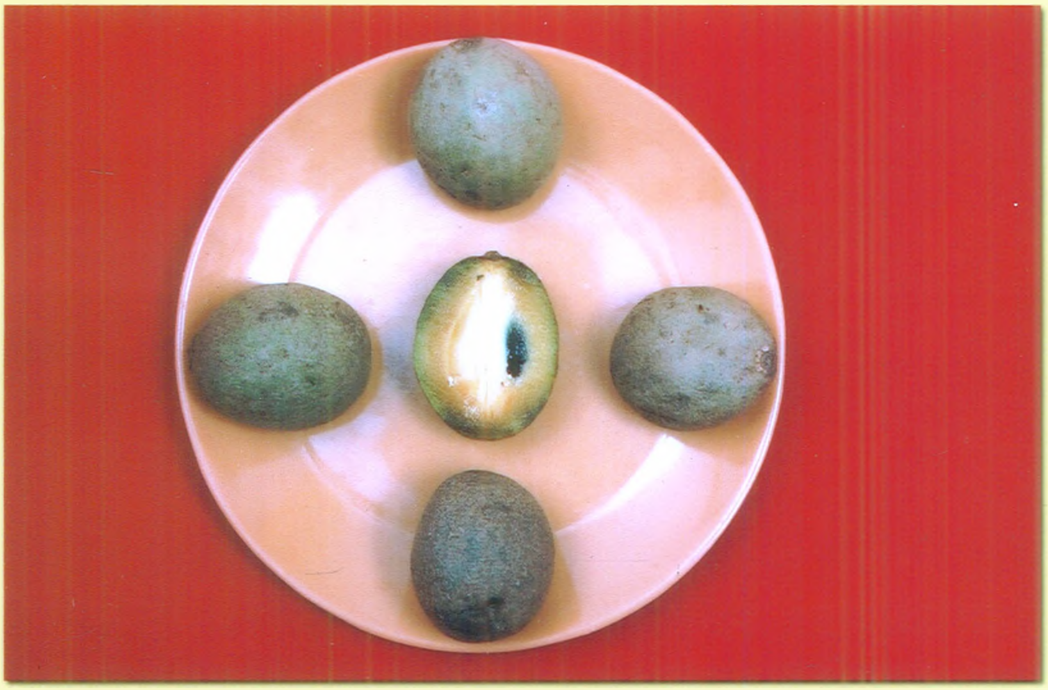
B. Identification of Suitable Method for Dehydration of Papaya and Sapota

Fruits tend to be juicy because of their high water content approximately 75 to 90 per cent which may accelerate spoilage. Moisture is required for chemical reactions and microbial growth. Control of moisture in fruits is thus very important from the point of view of preservation. There are many methods whereby moisture in foods can be safely altered or removed. These include drying, addition of salt, sugar, glycerol or other solutes or use of combination of these. Drying methods will reduce the water activity thereby inhibit or slow down the growth of microorganisms.

Among all the methods, sun drying is possibly the most appropriate way of preserving many fruits, since it has the advantage of



PAPAYA



SAPOTA

SAMPLES SELECTED FOR THE STUDY

PLATE 1

being a traditionally, well known technology and the cost of equipment is very low. During drying, water is removed from the surface of the product by the combined effects of the three basic elements namely temperature, humidity and air flow. Drying is successful only if the relationship between these elements is optimum.

The types of dehydration methods followed in the study included sundrying, hot air oven drying and solar drying. Dehydration methods like sundrying and solar drying have been selected because of the natural abundant source of solar energy, convenience, minimum cell destruction and inexpensiveness. Hot air oven drying was selected because it is more convenient and can be carried out at household level. The procedure followed for different methods are as follows.

1.Sun drying

Sun drying, a very convenient and cheap method has been used for drying papaya and sapota. This method is feasible only under climatic conditions of high heat and low humidity. Therefore sun drying was done during the month of February and March, when the sky was clear with hot climate. Fresh fruits weighing one kg each were dried under sunlight by placing slices of fruits on a clean aluminium tray covered with fine net for a period of 5-6 hours/day for 2 days at a variable temperature of 33-35°C. Fruits were turned twice a day and dried until the fruits lost most of its moisture and felt crisp.

2. Solar drying

Solar driers make use of non-conventional source of energy namely sunlight, which is abundantly available in India. This method has the advantage of retaining the original flavour of the food and the cost of the instrument has also been kept within the reach of the common man. In addition, there is no danger of overheating. Papaya and sapota pieces were weighed and one kg each were taken in aluminium trays and kept in the Box type Solar Drier (Cabinet drier) and exposed to sunlight . The fruit pieces were kept in a single layer to facilitate uniform drying. Mostly solar drying is much faster at the end of drying period, so a close monitoring was done to avoid burning of fruit pieces. The time taken for the samples to dry varied according to the design of the drier and intensity of the sunlight available and in the present study the fruit pieces were dried within 7-8 hours at 35 - 36°C (maximum temperature inside the solar cooker).

3. Hot air oven drying

Dehydration in hot air oven is more flexible as to the type and size of operation and are highly suitable for small scale operation (Salunkhe et al., 1991). Weighed amount of one kg of sliced papaya and sapota pieces were dried separately in the heated chamber maintained at a temperature of 60°C for 5½-6 hours. The method was standardised with small quantities by varying the time and temperature of drying.

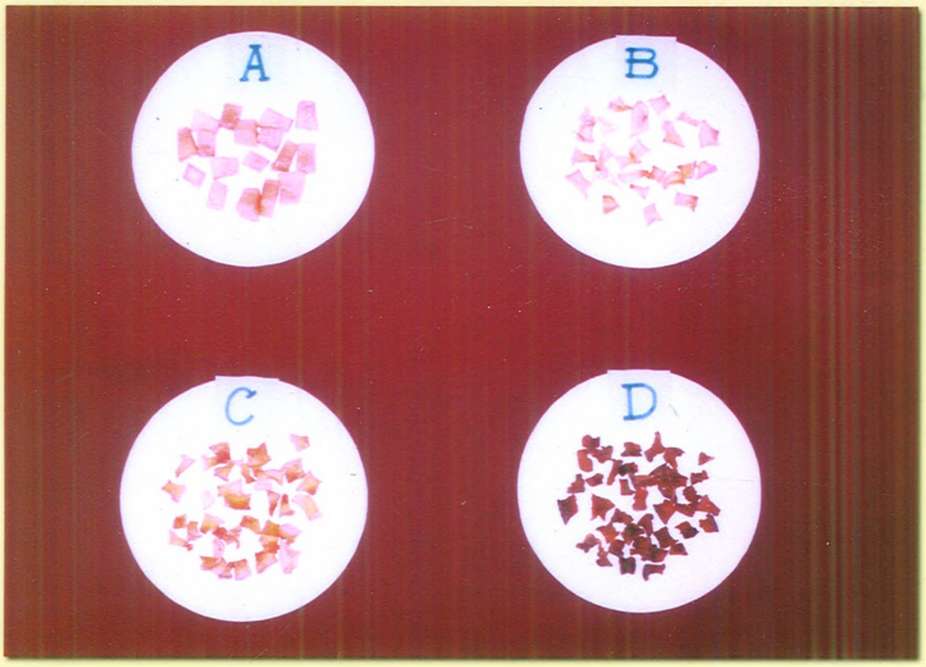
Fruit pieces were spread in a single layer on a tray and kept inside the oven and periodically checked and turned the pieces to get uniform drying. The dried pieces were taken from the oven after ensuring maximum amount of moisture removal.

C. Analysis of Nutrients and Selection of Suitable Papaya and Sapota Powders for Further Study

The samples obtained after drying by the selected three methods (Plate 2) were powdered separately using a household mixie to get a fine powder. The dried powders were used for nutrient analysis and for the development of nutritious mixes.

Energy content of the powders was determined using Oxygen Bomb Calorimeter. The protein content was estimated using Kjeltech distillation system.

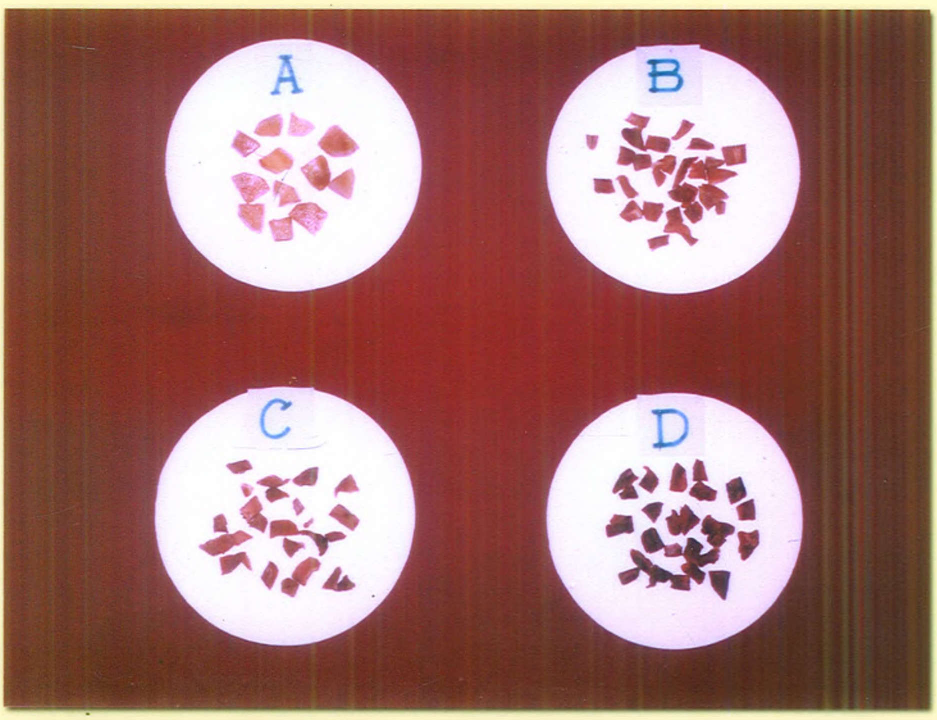
Determination of moisture, ash, carbohydrate, thiamine, riboflavin, calcium, phosphorus and iron were carried out following AOAC (1990) procedures. The acid content of the samples was determined by adding approximately 20 ml of water to a known weight of dried sample and titrating against 0.1N NaoH, using phenolphthalein as indicator (Ranganna,1986). Estimation of ascorbic acid by 2,6 dichlorophenol indophenol method and reducing sugar by Nelson-Somogyi method (Ranganna, 1986) were also done. Total carotene was analysed by spectrophotometry (Plate 3) and beta carotene by HPLC method (Plate 4). The modified NIN method based on the procedure of Zakaria et al., (1979) was followed for both the analysis (Appendix I). All the estimations were done in duplicates and the mean values were found out.



PAPAYA IN ITS RAW AND DEHYDRATED FORMS

A : Raw papaya B : Sun drying

C : Hot air oven drying D : Solar drying



SAPOTA IN ITS RAW AND DEHYDRATED FORMS

A : Raw sapota B : Sun drying

C : Hot air oven drying D : Solar drying

PLATE 2

ANALYSIS OF TOTAL CAROTENE BY SPECTRO-PHOTOMETRY

PLATE 3

ANALYSIS OF BETA CAROTENE BY HIGH PER-FORMANCE LIQUID CHROMATOGRAPHY

PLATE 4

Among the three methods solar drying was found to be better in many aspects such as good retention of nutrients and good acceptability of final product. Because of these best qualities solar dried fruit powders were selected for the development of the nutritious mixes.

D. Formulation and Preparation of Nutritious Mixes Incorporated with Solar Dried Papaya and Sapota Powders

1. Selection of Ingredients

Rice, wheat, jowar, bajra and ragi are the common cereals which play an important role in Indian dietaries. The major pulses, which find an important place in Indian cuisine are redgram, bengal gram, black gram, green gram and lentils. Groundnut is an important oil seed grown in large quantities in our country. Sugar and jaggery are sweetening agents used in beverages and other foods to increase palatability.

In the present study, wheat and ragi were selected as the staple cereal ingredients for the development of nutritious mixes, since they contain significant amounts of carbohydrates, protein, minerals and vitamins. To increase the nutritive value of the mix protein rich pulses like green gram and roasted bengal gram were also selected.

In addition, the protein and energy value of the mix was increased by adding groundnut. According to ICMR (2000) among the sweetening agents jaggery contains more iron and also contributes energy. Hence jaggery was selected for incorporation to provide iron and sweet taste to the mixes. Apart from all these ingredients papaya and sapota powders formed the special additive ingredients of the mixes to provide micronutrients (Plate 5).

A : Wheat
B : Ragi
C : Roasted Bengal Gram
D : Green Gram
E : Papaya (dried)
F : Sapota (dried)
G : Groundnut
H : Jaggery

RAW INGREDIENTS USED IN THE FORMULATION OF NUTRITIOUS MIXES

PLATE 5

2. Preparation of nutritious mixes

Ingredients namely ragi, wheat, roasted bengal gram, green gram and groundnuts were purchased from the local market and cleaned thoroughly. Then they were roasted and powdered in a flour mill and used for the preparation of nutritious mixes (Plate 6). "Kuzhandai Amudhu" - a nutritious food developed by Devadas et al., (1974) was chosen as the base for the present study. The composition of the mix was cereal, pulse, groundnut and jaggery in the ratio of 3:2:1:2 which was found to be well accepted in the community and had the potential to improve the nutritional status of the targetted population namely children. The composition of "Kuzhandai Amudhu" was slightly modified to lend for the incorporation of dehydrated papaya and sapota powders.

E. Acceptability Testing of the Developed Nutritious Mixes

Quality is the ultimate criterian for the desirability of any food product, ruled over by the organoleptic properties such as appearance, colour, texture, flavour and taste. A five point scale score card was developed (Appendix II) on the basis of numerical rating scale and used for acceptability testing.

The acceptability test was carried out by selected 15 taste panel members constituted by the staff and post graduate students of Nutrition Department of the University. Mixes with 10 per cent level of fruit powder incorporation got maximum scores from the panel members as revealed from Table I and hence these combinations were selected for further study. The composition of the highly accepted ragi and wheat based nutritious mixes is indicated in Table II.

R_1 : R + RBG + G + J + P

R_2 : R + GG + G + J + P

R_3 : R + RBG + G + J + S

R_4 : R + GG + G + J + S

RAGI BASED NUTRITIOUS MIXES

W_1 : R + RBG + G + J + P

W_2 : R + GG + G + J + P

W_3 : R + RBG + G + J + S

W_4 : R + GG + G + J + S

WHEAT BASED NUTRITIOUS MIXES

PLATE 6

TABLE I

MEAN SCORES OF NUTRITIOUS MIXES INCORPORATED WITH DEHYDRATED PAPAYA AND SAPOTA POWDERS

(Maximum score : 25)

Level of Incorporation	Papaya		Sapota	
	Ragi based	Wheat based	Ragi based	Wheat based
5%	21.0	21.2	20.0	20.3
10%	21.4	21.8	20.5	20.8
15%	19.7	21.0	19.2	19.6
20%	17.5	17.8	18.2	18.4

TABLE II

COMPOSITION OF THE HIGHLY ACCEPTED NUTRITIOUS MIXES

S.No	Ingredients	Amount (g)	Ingredients	Amount (g)
	Ragi Based (R)		**Wheat Based (W)**	
1.	Ragi	35.0	Wheat	35.0
2.	Bengal gram/green gram	22.5	Bengal gram/green gram	22.5
3.	Groundnut	10.0	Groundnut	10.0
4.	Dehydrated fruit powder	10.0	Dehydrated fruit powder	10.0
5.	Jaggery	22.5	Jaggery	22.5
Total		**100.0**		**100.0**

F. Analysis of Nutrients of the Highly Accepted Papaya and Sapota Powder Incorporated Nutritious Mixes

Four ragi based and four wheat based nutritious mixes were found to be most acceptable and hence these eight mixes were subjected to nutrient analysis.

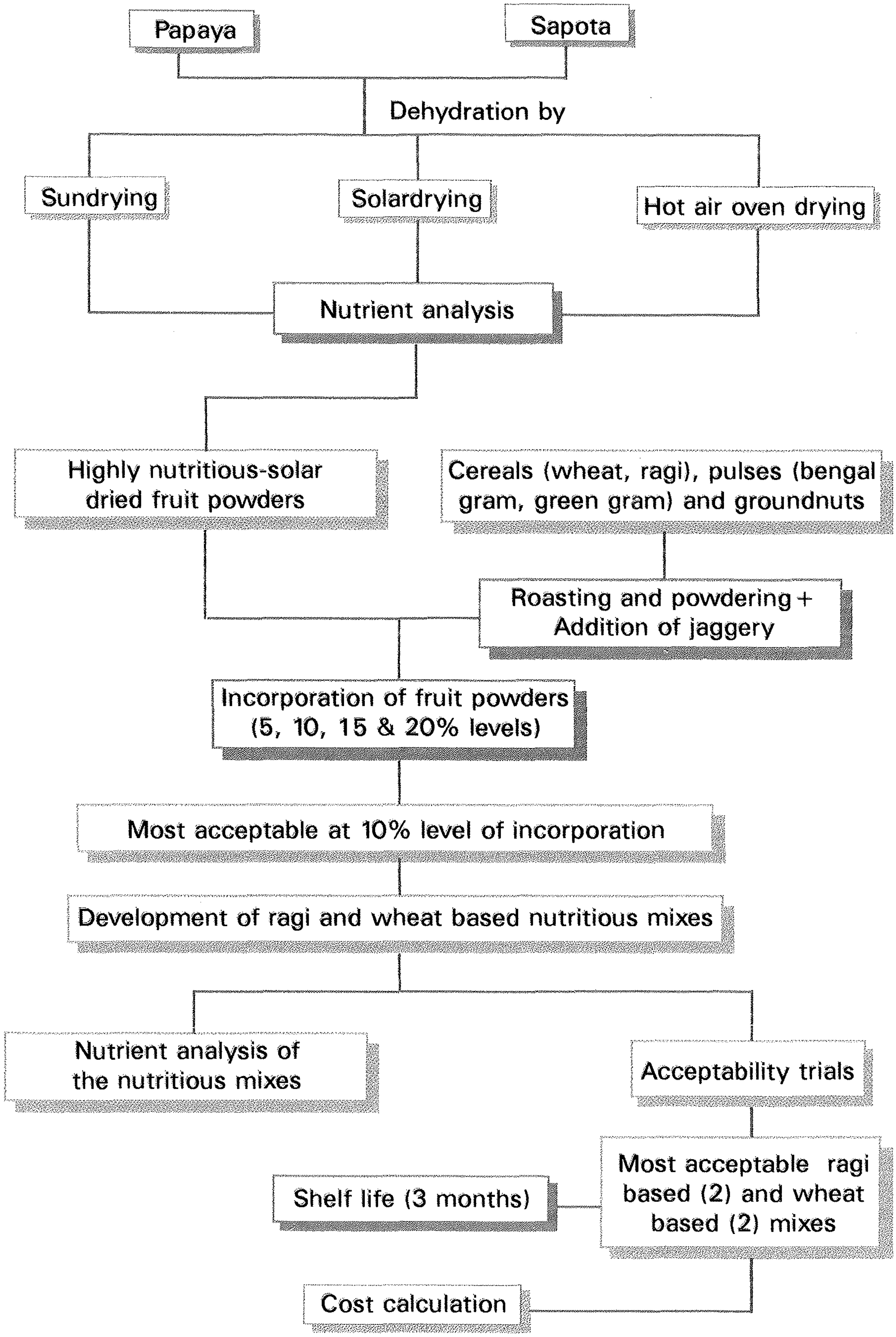
The nutrients selected for the analysis in the mixes include energy (Oxygen Bomb Caloriemeter), protein (Kjeltech Distillation System), carbohydrate (Anthrone method), iron, calcium, phosphorus (AOAC procedures), vitamin C (Dye method), Thiamine and riboflavin (Flourescent method), titrable acidity and total and beta carotene (HPLC method). The procedures followed are the same as mentioned for analysis of papaya and sapota powders.

G. Keeping Quality and Cost of the Highly Accepted Nutritious Mixes

Acceptability trials revealed that in both ragi and wheat based nutritious mixes incorporated with roasted bengal gram with papaya and sapota powders ranked first and those with green gram incorporated nutritious mixes ranked second. Hence the nutritious mixes with bengal gram dhal was selected for shelf life studies.

These mixes were packed in polyethylene bags of 50g each sealed and kept at room temperature and in the refrigerator for 90 days. Every month, the changes in storage were observed in terms of quality and nutrient content. The samples were analysed for proximate principles, vitamin and mineral contents.

Calculation of the cost of the mixes will help us to evaluate the feasibility of the mixes for commercial exploitation. The cost of the developed nutritious mixes was calculated by making use of the cost of the raw materials prevalent in the market at the time of the study.



EXPERIMENTAL DESIGN OF THE STUDY

FIGURE 1

RESULTS AND DISCUSSION

IV RESULTS AND DISCUSSION

The results obtained in the present study entitled "Formulation and Evaluation of Nutritious Mixes Incorporated with Papaya and Sapota Powders" are discussed under the following headings:

A. Details on Drying of Papaya and Sapota Fruits

B. Nutrient Content of Papaya and Sapota Powders obtained by Different Methods of Drying

C. Nutritive Value of the Formulated Nutritious Mixes

D. Acceptability of the Formulated Nutritious Mixes

E. Keeping Quality of the Highly Accepted Nutritious Mixes and

F. Cost of the Highly Accepted Nutritious Mixes

A. DETAILS ON DRYING OF PAPAYA AND SAPOTA FRUITS

Table III presents the drying details namely time, temperature, yield and acceptability scores of fruit powders obtained by sun drying, solar drying and hot air oven drying methods.

TABLE III

DRYING TIME, TEMPERATURE, YIELD AND MEAN ACCEPTABILITY SCORES OF PAPAYA AND SAPOTA POWDERS

S.No	Details	Sundrying		Solar drying		Hot air oven drying	
		Papaya	Sapota	Papaya	Sapota	Papaya	Sapota
1.	Drying time (in hrs)	13	12	8	7	6	5.5
2.	Temperature (°C)	34	33	35	36	60	60
3.	Yield (g/kg of raw fruit)	252	240	241	233	235	230
	Mean Acceptability Scores (Max : 25)						
	a. Appearance (5)	3.25	3.51	4.55	4.60	3.75	4.58
	b. Colour (5)	3.40	3.60	4.70	4.54	3.90	4.20
	c. Texture (5)	4.45	4.45	4.60	4.55	4.55	4.80
	d. Flavour (5)	3.27	4.25	4.25	4.40	3.60	4.35
	e. Taste (5)	4.00	4.37	4.29	4.50	4.15	4.45
	Total	18.37	20.18	22.39	22.59	19.95	22.38

It is observed from the table that among the three drying methods, the time taken for drying the fruits was found to be minimum with 5½ - 6 hours in hot air oven drying compared to solar drying and sun drying where the time taken for drying ranged from 11 to 13 hours. The time taken for sun drying and solar drying was found to be twice as that of hot air oven drying.

The temperature of drying was found to be more or less similar for both both sundrying and solar drying with a range of 33 to 36° C whereas hot air oven drying was carried out at a higher temperature of 60°C.

When the fruits were subjected to various methods of drying, the yield of fruit powder in grams per kilogram of fruit pulp ranged from 233 to 252 grams with a maximum of 240 to 252 grams for sun dried samples. This increased weight may be attributed to the phenomenon of incomplete moisture removal in sun drying in comparison with a greater moisture removal among solar and hot air oven dried samples.

Among the selected three methods solar dried samples were found to be superior in terms of higher acceptability scores for appearance, colour, texture, flavour and taste compared to sun dried and hot air oven dried fruit powders. Texture and taste scores were similar among all the three methods, whereas the scores for appearance, colour and flavour of sundried and hotair oven dried samples were found to be lesser than solar dried items.

B. NUTRIENT CONTENT OF PAPAYA AND SAPOTA POWDERS OBTAINED BY DIFFERENT METHODS OF DRYING

The analysed values of the nutrient content of papaya and sapota powders got by the three drying methods are presented in Table IV and Figure 2 and 3.

TABLE IV

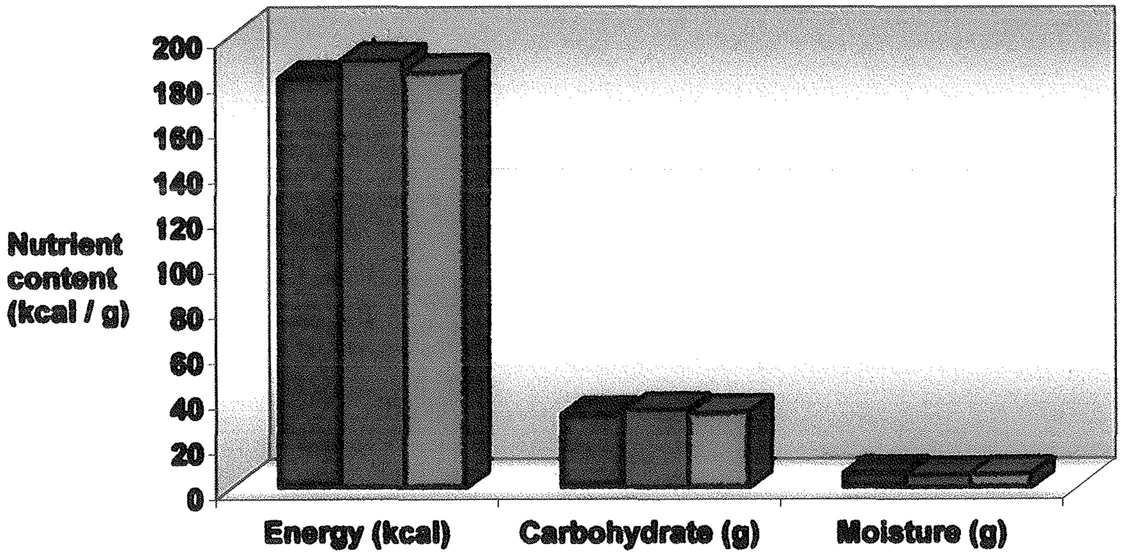
ENERGY, PROTEIN, CARBOHYDRATE, MOISTURE, ASH AND MINERAL CONTENT OF PAPAYA AND SAPOTA POWDERS

S.No	Nutrients	Papaya Powder			Sapota Powder		
		Sun drying	Solar drying	Hot air oven drying	Sun drying	Solar drying	Hot air oven drying
1.	Energy (Kcal)	181	189	184	274	280	275
2.	Protein (g)	0.36	0.40	0.38	0.48	0.51	0.50
3.	Carbohydrate (g)	32.0	34	33	38	42	40
4.	Moisture (g)	6.1	5.4	5.8	7.9	7.1	7.3
5.	Ash (g)	0.58	0.64	0.60	0.47	0.57	0.50
6.	Calcium (mg)	28.0	29.0	27.6	40.0	43.0	42.0
7.	Phosphorus (mg)	36.0	36.8	36.5	50.0	61.0	54.0
8.	Iron (mg)	0.8	0.9	0.84	2.3	2.62	2.4

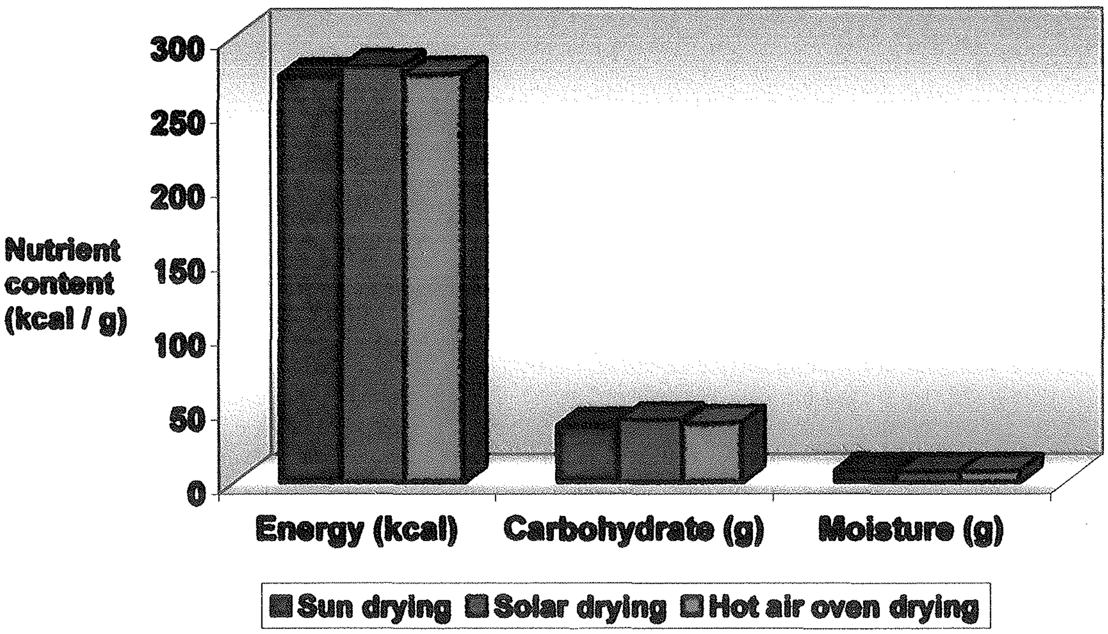
Sapota powders were found to provide more energy with a value of 274 to 280 Kcal per 100 grams in comparison with papaya powders which contained only 181 to 189 Kcal. Solar dried papaya and sapota powders were found to have slightly higher energy values in comparison with sun dried and oven dried samples.

In general, fruits are poor sources of protein which is evident from the values of 0.36 to 0.4 grams in papaya and 0.48 to 0.5 grams in sapota powders of 100 grams. Values were slightly higher for solar dried samples.

The relatively higher carbohydrate content observed among sapota powders may be attributed to its high sugar content. The carbohydrate values ranged from 32 to 34 grams per cent for papaya powders and 38 to 42 grams per cent for sapota powders, with solar dried samples showing the maximum carbohydrate content.

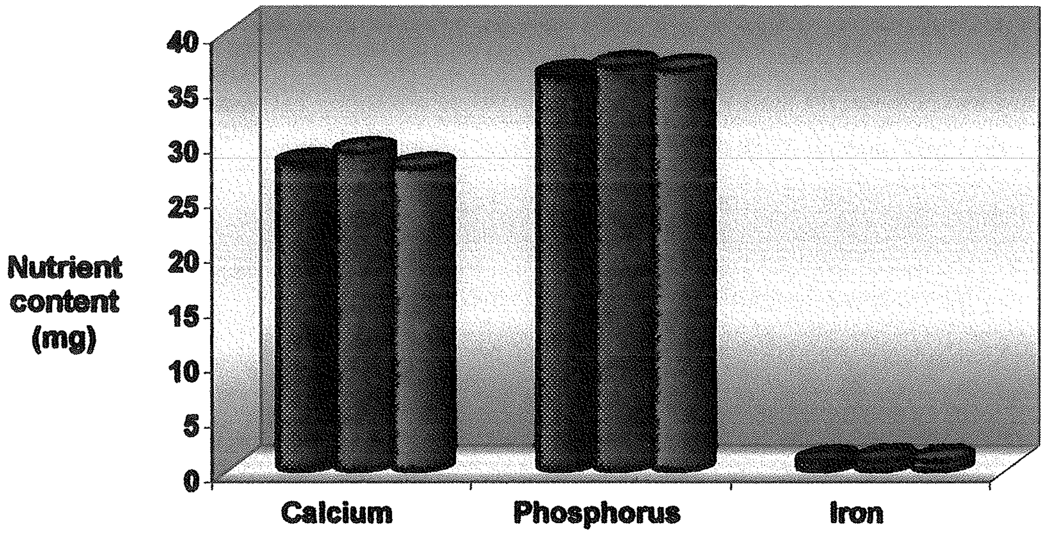


ENERGY, CARBOHYDRATE AND MOISTURE CONTENT OF PAPAYA POWDERS

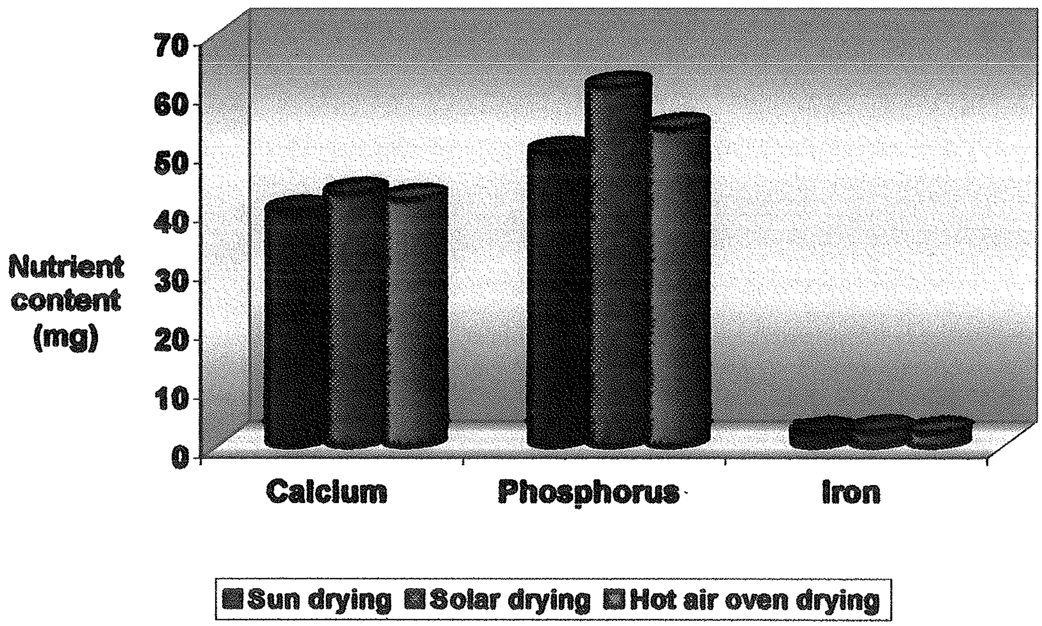


ENERGY, CARBOHYDRATE AND MOISTURE CONTENT OF SAPOTA POWDERS

FIGURE 2



CALCIUM, PHOSPHORUS AND IRON CONTENT OF PAPAYA POWDERS



CALCIUM, PHOSPHORUS AND IRON CONTENT OF SAPOTA POWDERS

FIGURE 3

Moisture content was found to be very low with value of 5.4 grams per cent for papaya powder and 7.1 grams per cent for sapota powder in the case of solar dried samples. The values for moisture were high among sun dried and hot air oven dried samples.

With regard to ash content, it was more for papaya powder namely 0.64 grams per cent compared to only 0.57 grams per cent among sapota powders got by solar drying. The ash content was lesser among sun dried and hot air oven dried samples.

Calcium, phosphorus and iron content of the papaya powders obtained by solar drying were found to be 29.0 mg, 36.8 mg and 0.9mg per100 grams per cent respectively, which were found to be more than the sun dried and hot air oven dried samples. Sapota powders obtained by solar drying contained 43.0 mg, 61.0 mg and 2.62 mg per cent of calcium, phosphorus and iron respectively compared to low values obtained by the other two methods of drying. The mineral content was found to be higher among sapota powder than papaya powders. In general, among the three methods of drying solar drying resulted in a highly nutritious dried powder than the other two methods.

Deepa and Lakshmi (2000) reported that 100 grams of papaya powders obtained by oven and sun drying contained 25.4 mg and 25.2 mg, 32.5 mg and 32.4 mg and 0.93 mg and 0.92mg of calcium, phosphorus and iron respectively.

Table V presents the values of vitamins, reducing sugar, acidity and TSS of papaya and sapota powders. Figure 4 and 5 shows the content of vitamin C, beta carotene, total carotene, reducing sugar and TSS of papaya and sapota powders.

TABLE V

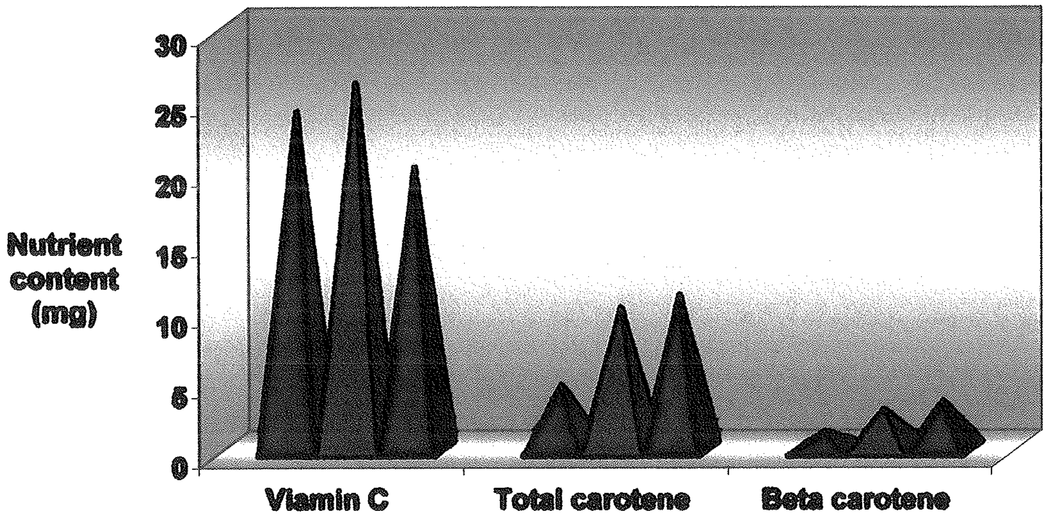
VITAMINS, REDUCING SUGAR, ACIDITY AND TSS VALUES OF PAPAYA AND SAPOTA POWDERS

S.No	Nutrients	Papaya Powder			Sapota Powder		
		Sun drying	Solar drying	Hot air oven drying	Sun drying	Solar drying	Hot air oven drying
1.	Thiamine (mg)	0.014	0.02	0.01	0	0.004	0.002
2.	Riboflavin (mg)	0.009	0.01	0.007	0.002	0.005	0.004
3.	Vitamin C (mg)	24.0	26.0	20.0	2.0	3.0	2.0
4.	Total carotene (mg)	4.569	10.067	11.008	0.718	1.591	1.746
5.	Betacarotene (mg)	1.215	2.816	3.427	0.190	0.435	0.540
6.	Reducing sugar (g)	10.0	10.9	9.8	10.2	13.3	11.2
7.	Acidity	0.38	0.40	0.36	0.46	0.47	0.43
8.	TSS (^{0} Brix)	35.0	36.4	34.2	36.2	37.6	36.4

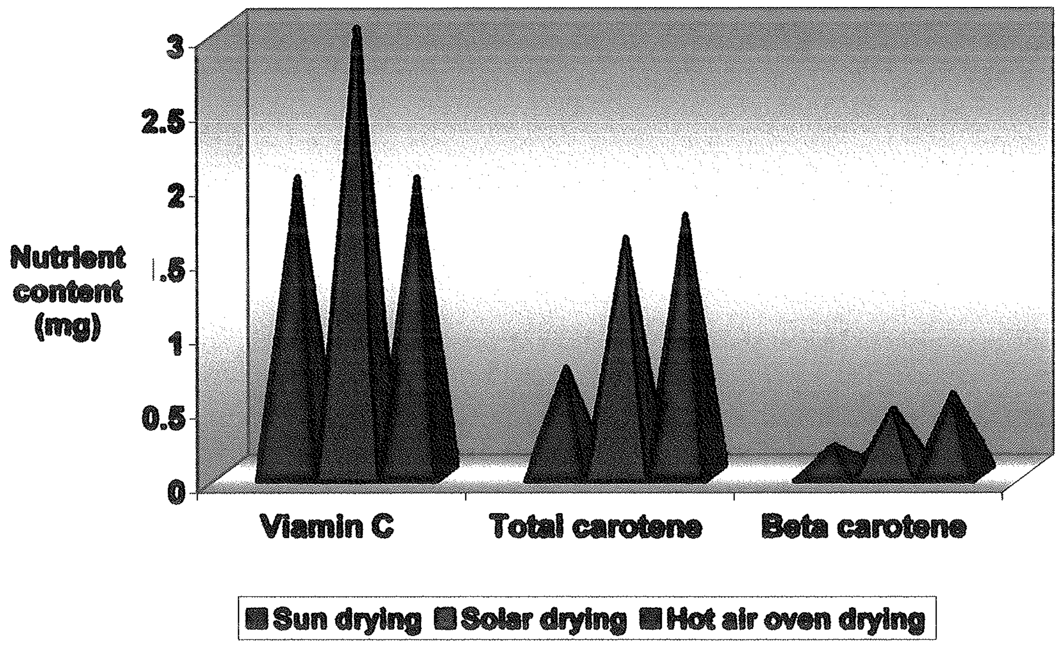
Papaya and sapota powders had negligible amounts of thiamine and riboflavin. Among the three methods, solar dried papaya powder had 0.02 mg and 0.01 mg per cent of thiamine and riboflavin respectively whereas, sapota powder had 0.004 mg and 0.005 mg/100g,being the highest values when compared to sun and hot air oven dried samples.

Ascorbic acid is lost due to oxidation while drying to the extent of 75 per cent. Papaya had ascorbic acid in the range of 20 to 26 mg per cent with a maximum for solar dried powder whereas sapota had only 2 to 3 mg per cent. Papaya is a rich source of carotene and vitamin C besides minerals (Aruna et al., 1998).

Carotene which is the precursor of vitamin A, is present in abundant amounts in papaya, which will give us significant amounts of carotene

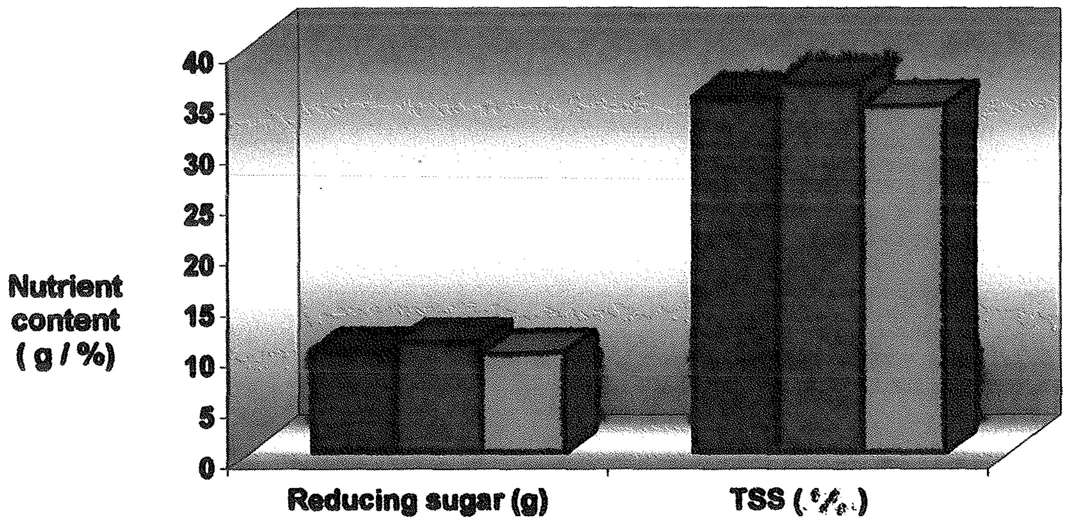


VITAMIN C, TOTAL AND BETA CAROTENE CONTENT OF PAPAYA POWDERS

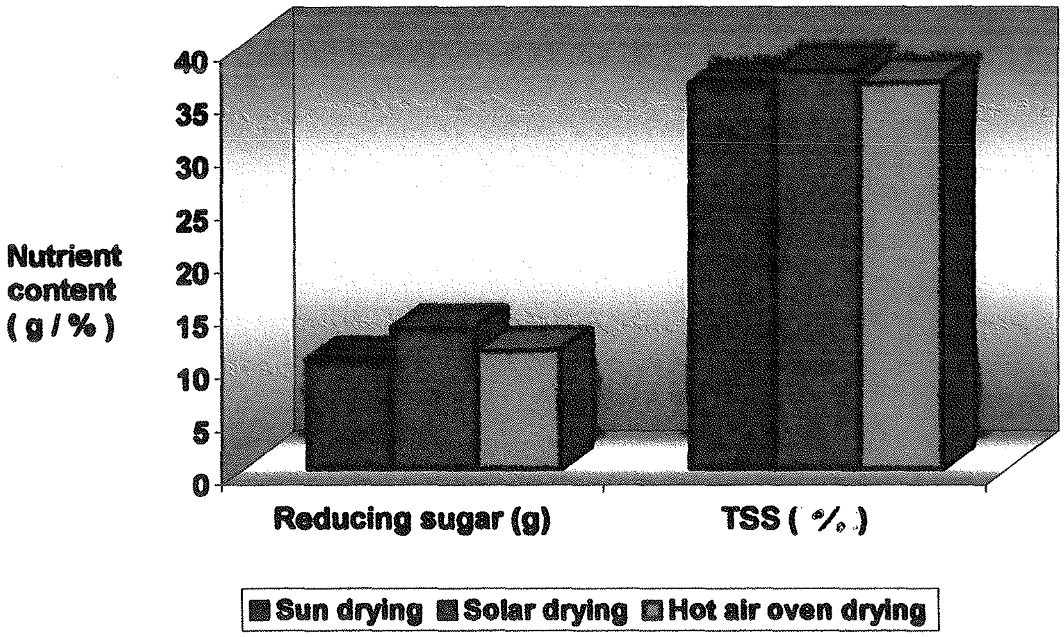


VITAMIN C, TOTAL AND BETA CAROTENE CONTENT OF SAPOTA POWDERS

FIGURE 4



REDUCING SUGAR AND TSS CONTENT OF
PAPAYA POWDERS



REDUCING SUGAR AND TSS CONTENT OF
SAPOTA POWDERS
FIGURE 5

on consumption. Sapota also provides significant amounts of beta carotenes. Total and beta carotene contents of hot air oven dried papaya powder was 11.008 mg and 3.427mg per 100g being the highest compared to sundried and solar dried samples. Similarly, sapota powder of hot air oven drying contained 1.746 mg of total carotene and 0.540 mg of beta carotene per100 gram when compared to the lower values reported among the other two methods of drying. Sun drying resulted in greater loss of total and beta carotene than solar and hot air oven drying. Chandrasekar and Kowsalya (2000) reported that solar dried papaya contained total carotene of 10.06 mg/100g.

Other components like reducing sugars, acidity and Total Soluble Solids (TSS) contents were retained to a maximum extent in solar drying compared to sun and hot air oven drying. Deepa and Lakshmi (2000) also noticed that oven dried and sundried papaya powders had a reducing sugar content of 10.32 g and 9.5 g per cent respectively which were less than the solar dried powder.

Solar dried sapota powder had a high amount of reducing sugar namely 13.3 g per cent whereas papaya powder had 10.9 g per cent only. Acid content of solar dried samples was found to be maximum with 0.47 g per cent for sapota and 0.4g per cent for papaya powder.

Results of the nutrient analysis revealed that papaya and sapota powders obtained by solar drying were found to be more nutritious than other methods of drying. This revealed the fact that solar drying was the best method with minimum loss of nutrients. Hence solar dried papaya and sapota powders were selected for incorporation into the newly formulated nutritious mixes.

C.NUTRITIVE VALUE OF THE FORMULATED NUTRITIOUS MIXES

1. Energy, Carbohydrates and Protein Content

The energy, carbohydrates and protein content of the formulated nutritious mixes incorporated with papaya and sapota powders are presented in Table VI.

TABLE VI

ENERGY , CARBOHYDRATES AND PROTEIN CONTENT OF THE NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

(In 100g)

S.No.	Nutritious Mixes	Energy (Kcal)	Carbohydrates (g)	Protein (g)
	PAPAYA POWDER			
	RAGI BASED			
1.	R_1 (R+RBG+G+J+P)	340	65.0	11.2
2.	R_2 (R+GG+G+J+P)	335	58.4	10.2
	WHEAT BASED			
3.	W_1 (W+RBG+G+J+P)	350	67.0	11.8
4.	W_2 (W+GG+G+J+P)	340	69.0	11.1
	SAPOTA POWDER			
	RAGI BASED			
5.	R_3 (R+RBG+G+J+S)	370	75.0	11.6
6.	R_4 (R+GG+G+J+S)	360	65.0	10.3
	WHEAT BASED			
7.	W_3 (W+RBG+G+J+S)	375	75.0	11.8
8.	W_4 (W+GG+G+J+S)	350	75.7	11.0

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

From the table it was observed that all the four ragi based formulations incorporated with papaya and sapota had an energy content ranging from 335-370 kcal. Similarly all the four wheat based formulations with papaya and sapota had an energy value of 340 to 375 kcal.

The formulated nutritious mixes provided 335 to 375 kcals per 100 g equivalent to one third of the daily requirement of preschool children. Both ragi and wheat based formulations provide adequate energy to fill the calorie gap of 300 kcal (Rao, 1999) commonly observed among preschoolers in the general population.

The carbohydrate content of the papaya and sapota incorporated ragi based nutritious mixes were found to be in the range of 58.4 to 75 grams, whereas wheat based nutritious mixes had a higher range of 67 to 75.7 grams of carbohydrate per 100 grams. Carbohydrate content was found to be more among sapota powder incorporated samples (65 to 75.7 %) than among samples with papaya powder incorporation (58.4 to 69 %).

The protein content of the papaya and sapota powder incorporated ragi based formulations ranged from 10.2 to 11.6 g and that of the wheat based formulations ranged from 11 to 11.82 g per cent. Wheat based formulations provided higher quantities of protein when compared to ragi based formulations. The protein content of papaya and sapota powder incorporated mixes were not significantly different.

In general, the energy ,carbohydrate and protein content of the roasted bengal gram incorporated samples (R_1, W_1, R_3 and W_3) of papaya and sapota were found to be slightly higher than the green gram incorporated samples (R_2, W_2, R_4 and W_4).

Gahlawat and Seghal (1993) showed that a combination of cereal, pulse and jaggery in the ratio of 70:30:25 provided 347.5 to 364 kcals per cent. Chandrasekhar et al (1988) developed a malted weaning food based on low cost locally available foods with a combination of malted ragi, malted horse gram and roasted groundnuts in the ratio of 65:25:10. Energy content of 100 g of the malted weaning food was 351 kcal. The results obtained in the present study are comparable to these studies.

2. Moisture and ash content

Table VII gives the moisture and ash contents of the developed nutritious mixes incorporated with papaya and sapota powders.

TABLE VII

MOISTURE AND ASH CONTENT OF THE NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

(In 100g)

S.No.	Nutritious Mixes	Moisture (g)	Ash (g)
	PAPAYA POWDER		
	RAGI BASED		
1.	R_1 (R+RBG+G+J+P)	4.7	2.11
2.	R_2 (R+GG+G+J+P)	5.5	2.21
	WHEAT BASED		
3.	W_1 (W+RBG+G+J+P)	5.0	1.71
4.	W_2 (W+GG+G+J+P)	5.1	1.9
	SAPOTA POWDER		
	RAGI BASED		
5.	R_3 (R+RBG+G+J+S)	5.1	2.2
6.	R_4 (R+GG+G+J+S)	6.0	2.1
	WHEAT BASED		
7.	W_3 (W+RBG+G+J+S)	5.1	1.8
8.	W_4 (W+GG+G+J+S)	5.6	1.7

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder .

Ragi based nutritious mixes had moisture and ash contents ranging from 4.7 to 6.0 grams and 2.1 to 2.21 grams per cent respectively, whereas wheat based nutritious mixes had moisture content in the range of 5.0 to 5.6 and slightly lower ash content of 1.7 to 1.9 gram per cent respectively. Low moisture content observed in the present study might be the contributing factor for good keeping quality of these nutritious mixes. Moisture and ash contents of the developed nutritious mixes were within the ISI (1956 – 1969) specifications of a maximum of 10.0 per cent and 5.0 per cent respectively.

Studies done by Gahlawat and Seghal (1993) showed that a combination of cereal, pulse and jaggery in the ratio of 70:30:25 contained 5.45 g to 6.15 g of moisture and 13.88 to 14.17 g of protein in 100g.

3. Thiamine, Riboflavin and Ascorbic Acid Content

Table VIII shows the thiamine, riboflavin and ascorbic acid content of the developed nutritious mixes incorporated with papaya and sapota powders.

TABLE VIII

THIAMINE, RIBOFLAVIN AND ASCORBIC ACID CONTENT OF THE NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

(In 100 g)

S.No.	Nutritious Mixes	Thiamine (mg)	Riboflavin (mg)	Ascorbic acid (mg)
	PAPAYA POWDER			
	RAGI BASED			
1.	R_1 (R+RBG+G+J+P)	0.15	0.04	1.1
2.	R_2 (R+GG+G+J+P)	0.22	0.09	1.1
	WHEAT BASED			
3.	W_1 (W+RBG+G+J+P)	0.10	0.01	1.1
4.	W_2 (W+GG+G+J+P)	0.10	0.04	1.0
	SAPOTA POWDER			
	RAGI BASED			
5.	R_3 (R+RBG+G+J+S)	0.12	0.03	0.0
6.	R_4 (R+GG+G+J+S)	0.20	0.08	0.0
	WHEAT BASED			
7.	W_3 (W+RBG+G+J+S)	0.08	0.0	0.0
8.	W_4 (W+GG+G+J+S)	0.08	0.03	0.0

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

With regard to water soluble vitamins like thiamine and riboflavin, the ragi based formulations contained from 0.12 to 0.22 mg and 0.03 to 0.09 mg per 100g respectively. Similarly wheat based formulations had thiamine and riboflavin contents ranging from 0.08 to 0.10 mg and 0 to 0.04 mg per cent respectively.

Ragi and greengram mixes incorporated with papaya powder had the maximum content of thiamine namely 0.22 mg per cent and riboflavin 0.09 mg per cent being the higher among all the samples.

All the formulated nutritious mixes with sapota incorporation had no ascorbic acid, whereas papaya incorporated nutritious mixes had very low amount with a value of 1.0 mg of ascorbic acid.

4. Total and Beta carotene Content

The fruits selected for the study are those which contained appreciable amounts of carotenoids. The total and beta carotene content of the formulated nutritious mixes incorporated with papaya and sapota powders are presented in Table IX.

TABLE IX

TOTAL AND BETA CAROTENE CONTENT OF THE NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

(In 100g)

S.No.	Nutritious Mixes	Total Carotene (mcg/100g)	Beta Carotene (mcg/100g)
	PAPAYA POWDER		
	RAGI BASED		
1.	R_1 (R+RBG+G+J+P)	380	190
2.	R_2 (R+GG+G+J+P)	310	170
	WHEAT BASED		
3.	W_1 (W+RBG+G+J+P)	390	210
4.	W_2 (W+GG+G+J+P)	315	200
	SAPOTA POWDER		
	RAGI BASED		
5.	R_3 (R+RBG+G+J+S)	80	50
6.	R_4 (R+GG+G+J+S)	70	40
	WHEAT BASED		
7.	W_3 (W+RBG+G+J+S)	90	60
8.	W_4 (W+GG+G+J+S)	85	45

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

Dehydrated fruits are concentrated sources of carotenes that can be made available in seasons of scarcity and inclusion of small amounts of these concentrated sources in dietaries can help to meet the daily beta carotene requirements of all the age groups.

The total carotene content of the papaya and sapota powder incorporated ragi based formulations were found to be in the range of 310 to 380 mcg / 100g and 70 to 80 mcg / 100g respectively. Whereas in wheat based formulations were found to be in the range of 315 to 390 mcg and 85 to 95 mcg/100g respectively.

Similarly the beta carotene content of the papaya and sapota powder incorporated ragi based formulations ranged from 170 to 190 mcg / 100g and 40 to 50 mcg/100g respectively. But in wheat based formulations contained in the range of 200 to 210 mcg/100g and 45 to 60 mcg/100g respectively being slightly higher than ragi based mixes.

It is evident from the findings that both total carotene and beta carotene contents were found to be higher among papaya based formulations with values ranging from 310 to 390 mcg in comparison to sapota incorporated mixes which had only 70 to 90 mcg per cent.

5. Calcium, Phosphorus and iron content

Table X shows the content of calcium, phosphorus and iron in the developed nutritious mixes incorporated with papaya and sapota powders.

TABLE X

CALCIUM, PHOSPHORUS AND IRON CONTENT OF THE NUTRITIOUS MIXES INCORPORATED WITH PAPAYA AND SAPOTA POWDERS

(In 100g)

S.No.	Nutritious Mixes	Calcium (mg)	Phosphorus (mg)	Iron (mg)
	PAPAYA POWDER			
	RAGI BASED			
1.	R_1 (R+RBG+G+J+P)	111.5	228.0	5.4
2.	R_2 (R+GG+G+J+P)	115.5	230.8	4.2
	WHEAT BASED			
3.	W_1 (W+RBG+G+J+P)	46.7	165.0	5.0
4.	W_2 (W+GG+G+J+P)	50.5	180.2	3.5
	SAPOTA POWDER			
	RAGI BASED			
5.	R_3 (R+RBG+G+J+S)	113.1	230.0	5.6
6.	R_4 (R+GG+G+J+S)	116.9	235.2	4.4
	WHEAT BASED			
7.	W_3 (W+RBG+G+J+S)	48.1	170.0	5.2
8.	W_4 (W+GG+G+J+S)	51.9	183.6	3.6

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

The calcium content of the ragi based formulations ranged from 111.5 to 116.9mg and this could provide nearly one third of the day's requirement namely 400 mg/day suggested by ICMR (2000) for preschoolers. The calcium content of the wheat based formulations ranged from 46.7 mg to 51.9mg /100g being lesser than ragi based mixes. The phosphorus content of the ragi based formulations ranged from 228 to 235.2mg per cent being the highest whereas wheat based formulations had only 165 to 183.6 mg per cent.

Ragi based formulations contained 4.2 to 5.6 mg of iron in 100 grams, wheat based formulations had almost a similar value of 3.5 to 5.2 mg per cent of iron. This iron is adequate to meet approximately 30 per cent of the day's requirement namely18mg/day of preschool children (ICMR, 2000).

In general, all the ragi based papaya or sapota powder incorporated mixes had a maximum amount of calcium, phosphorus and iron compared to wheat based mixes. Incorporation of papaya or sapota powder did not bring about significant differences among the contents of calcium, phosphorus and iron among both ragi and wheat based mixes.

6. Reducing Sugar, Titrable Acidity and Total Soluble Solids (TSS) Content

The amount of reducing sugar, titrable acidity and TSS present in the formulated nutritious mixes incorporated with papaya and sapota powders are given in Table XI.

TABLE XI

REDUCING SUGAR, TITRABLE ACIDITY AND TOTAL SOLUBLE SOLID CONTENT OF THE NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Reducing Sugar (g)	Titrable Acidity (g)	Total Soluble Solids (°Brix)
	PAPAYA POWDER			
	RAGI BASED			
1.	R_1 (R+RBG+G+J+P)	17.9	0.90	17.80
2.	R_2 (R+GG+G+J+P)	17.4	0.85	17.40
	WHEAT BASED			
3.	W_1 (W+RBG+G+J+P)	19.2	1.00	17.90
4.	W_2 (W+GG+G+J+P)	19.1	0.95	17.50
	SAPOTA POWDER			
	RAGI BASED			
5.	R_3 (R+RBG+G+J+S)	20.7	0.20	18.20
6.	R_4 (R+GG+G+J+S)	20.4	1.00	18.00
	WHEAT BASED			
7.	W_3 (W+RBG+G+J+S)	24.2	1.00	18.46
8.	W_4 (W+GG+G+J+S)	24.0	1.00	18.20

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

Reducing sugar content of the ragi and wheat based formulations incorporated with papaya and sapota powders ranged from 17.4 to 20.7 grams per cent and 19.1 to 24.2 grams per cent respectively. It is evident that sapota incorporated mixes had higher reducing sugar than papaya added mixes which may be attributed to the higher sweetness of sapota than papaya. Moreover ragi based mixes had lesser reducing sugar (17.4 to 20.7g%) than wheat based mixes (19.1 to 24.2g%). The higher reducing sugar content may provide ready energy to children and others to fill the calorie gap.

The titrable acidity content of the papaya based formulations ranged from 0.85 to 1.0g per cent whereas sapota based formulations had an acid content of 1.0 to 1.2g per cent. In general, cereal and pulse based nutritious mixes will not have acid as a component but since the nutritious mixes developed in the present study had fruits like papaya and sapota which contributed some acidity to the mixes ranging from 0.85 and 1.2 g per cent which is very much within the acceptable levels.

Total Soluble Solids present in sapota based formulations were slightly higher in the range of 18.0 to 18.5^0 Brix compared to papaya based formulations where it was in the range of 17.4 to 17.9^0 Brix.

D. ACCEPTABILITY OF THE FORMULATED NUTRITIOUS MIXES

The mean scores obtained for acceptability of ragi and wheat based nutritious mixes incorporated with papaya and sapota powders as judged by the panel members are presented in Table XII.

TABLE XII

MEAN ACCEPTABILITY SCORES OF THE FORMULATED RAGI AND WHEAT BASED NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Appearance (5)	Colour (5)	Texture (5)	Flavour (5)	Taste (5)	Overall Acceptibility (25)
	PAPAYA POWDER						
	RAGI BASED						
1.	R_1(R+RBG+G+J+P)	4.00	5.00	5.00	3.00	3.80	20.80
2.	R_2(R+GG+G+J+P)	3.10	5.00	4.70	3.60	3.40	19.78
	WHEAT BASED						
3.	W_1(W+RBG+G+J+P)	4.35	5.00	4.35	3.70	4.00	21.40
4.	W_2(W+GG+G+J+P)	4.05	4.60	4.60	3.45	3.95	20.65
	SAPOTA POWDER						
	RAGI BASED						
5.	R_3(R+RBG+G+J+S)	4.85	4.85	4.85	3.40	3.40	21.35
6.	R_4 (R+GG+G+J+S)	3.55	5.00	5.00	3.75	3.70	21.05
	WHEAT BASED						
7.	W_3(W+RBG+G+J+S)	4.35	5.00	4.35	3.70	4.50	21.90
8.	W_4(W+GG+G+J+S)	4.00	5.00	4.50	4.00	4.00	20.50

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

The results of the acceptability trials indicated that ragi and wheat based nutritious mixes incorporated with roasted bengal gram with papaya and sapota powders (R_1,W_1,R_3 and W_3) ranked first with scores of 20.8, 21.4,21.35 and 21.9 and those with green gram incorporated nutritious mixes ranked second with 19.78,20.65,21.05 and 20.50 scores out of a maximum scores of 25. Among all the nutritious mixes W_3 got the maximum score of 21.9.The nutritious mixes incorporated with roasted bengal gram ranked first probably due to the ability of bengal gram to blend well with other ingredients.

Incorporation of papaya or sapota did not affect the qualities like apperance, texture and colour but slightly lowered the scores for taste and flavour.Similarly ragi and wheat incorporation did not affect the scores significantly.

In general all the formulations were evaluated to be good by the taste panel members and none of the formulations got very poor scores. In particular bengal gram based formulations were found to be highly acceptable and hence selected for the shelf life studies.

E. KEEPING QUALITY OF THE HIGHER ACCEPTABILITY NUTRITIOUS MIXES

The highly accepted four nutritious mixes with roasted bengal gram, ragi and wheat added with papaya and sapota were taken and 50 g each were packed in polyethylene covers sealed and kept in plastic containers and evaluated for keeping quality over a period of three months at room temperature and in the refrigerator separately. Packets were drawn for analysis of various parameters at zero and ninety days of storage. At the end of ninety days, these samples were also evaluated, for their acceptability by the panel members.

1. Energy, Carbohydrate, Protein and Moisture Content of Stored Nutritious Mixes

Table XIII presents the energy, carbohydrate, protein and moisture content of the nutritious mixes stored compared with their fresh counterparts.

TABLE XIII

ENERGY, CARBOHYDRATE, PROTEIN AND MOISTURE CONTENT OF THE FRESH AND STORED NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Energy (Kcal)			Carbohydrate (g)			Protein (g)			Moisture (g)		
		Initial	After 3 months		Initial	After 3 months		Initial	After 3 months		Initial	After 3 months	
			Ref	RT		Ref	RT		Ref	RT		Ref	RT
	PAPAYA POWDER												
1.	R_1	340	342	340	65.0	65.2	65.1	11.2	11.2	11.1	4.7	5.7	5.9
2.	W_1	350	353	350	67.0	67.3	67.0	11.8	11.8	11.7	5.0	6.5	6.9
	SAPOTA POWDER												
3.	R_3	370	370	370	75.0	75.3	75.1	11.6	11.6	11.5	5.1	6.7	7.0
4.	W_3	375	376	375	75.0	75.3	75.0	11.8	11.8	11.7	5.1	6.8	7.1

Ref - Refrigerator RT - Room Temperature

R_1 - Ragi + Roasted bengal gram + Groundnut + Papaya powder + Jaggery

W_1 - Wheat + Roasted bengal gram + Groundnut + Papaya powder + Jaggery

R_3 - Ragi + Roasted bengal gram + Groundnut + Sapota powder + Jaggery

W_3 - Wheat + Roasted bengal gram + Groundnut + Sapota powder + Jaggery

The energy content of the ragi and wheat based formulations were found to be similar when stored at room temperature. Whereas ragi and wheat based formulations stored in the refrigerator showed a negligible increase (1 to 3 per cent) in its energy content after 90 days of storage.

The carbohydrate content of the ragi and wheat based formulations after storage showed a slight increase with the refrigerated samples having a slightly higher gain (0.3gm) than those stored at room temperature (0.1gm).

The protein content of the papaya and sapota powders incorporated ragi and wheat based formulations stored in the refrigerator showed no significant loss. While those stored at room temperature showed a slight loss by 0.1gm.

The gain in moisture was found to be slightly more for samples stored at room temperature when compared to refrigerated sample. Inspite of the increase in moisture content of the stored formulations (5.65 to 7.1 per cent) was less than the ISI specifications (maximum 10 per cent). In the present study, increase in moisture content was found to be very less revealing the possibility of better storage of these mixes for more than three months.

2. Thiamine,Riboflavin and Ascorbic Acid Content

Table XIV shows the thiamine, riboflavin and ascorbic acid contents of the nutritious mixes initially and after 90 days of storage at room and refrigerator temperature.

TABLE XIV

THIAMINE, RIBOFLAVIN AND ASCORBIC ACID CONTENTS OF THE FRESH AND STORED NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Thiamine (mg)			Riboflavin (mg)			Ascorbic acid (mg)		
		Initial	After 90 days		Initial	After 90 days		Initial	After 90 days	
			Ref	RT		Ref	RT		Ref	RT
	PAPAYA POWDER									
1.	R_1(R+RBG+G+J+P)	0.15	0.15	0.14	0.04	0.04	0.03	1.0	0.6	0.58
2.	W_1(W+RBG+G+J+P)	0.10	0.11	0.10	0.01	0.01	0.01	1.0	0.62	0.57
	SAPOTA POWDER									
3.	R_3(R+RBG+G+J+S)	0.12	0.12	0.11	0.03	0.03	0.02	0.0	0.00	0.00
4.	W_3(W+RBG+G+J+S)	·0.08	0.09	0.08	0.00	0.00	0.00	0.0	0.00	0.00

Ref : Refrigerator RT : Room Temperature

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

Thiamine content of the ragi and wheat based formulations stored in the refrigerator showed only a slight increase (0.01 per cent) whereas at room temperature 0.01 per cent reduction was observed. In the case of riboflavin also a slight reduction was observed among mixes stored at room temperature.

A significant reduction (40 per cent) of ascorbic acid was noticed among papaya powder incorporated mixes stored at refrigerator and room temperature. Ascorbic acid was not present among sapota powder added mixes.

3. Total and Beta carotene Content

Total and beta carotene content of the fresh and stored nutritious mixes are given in Table XV.

TABLE XV

TOTAL AND BETA CAROTENE CONTENTS OF THE FRESH AND STORED NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Total Carotene (mcg)			Beta Carotene (mcg)		
		Initial	After 90 days		Initial	After 90 days	
			Ref	RT		Ref	RT
	PAPAYA POWDER						
1.	R_1(R+RBG+G+J+P)	380	320	290	190	100	95
2.	W_1(W+RBG+G+J+P)	390	330	300	210	110	105
	SAPOTA POWDER						
3.	R_3(R+RBG+G+J+S)	80	60	50	50	40	25
4.	W_3(W+RBG+G+J+S)	90	70	60	60	45	30

Ref : Refrigerator RT : Room Temperature

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

Among the ragi based nutritious mixes the total carotene content was in the range of 80 to 380 mcg initially which decreased slightly after 90 days of storage in the refrigerator to a value of 60 to 320 mcg and at room temperature to a value of 50 to 290 mcg. This slight reduction may be due to the oxidation of the samples on storage. A similar trend was observed in wheat based formulations also.

With regard to beta carotene content, the ragi based formulations had 50 to 190 mcg initially, but after 90 days of storage in refrigerator the content decreased to 40 to 100 mcg. In the case of wheat based formulations the range was reduced from 60 to 210 mcg to 45 to 110 mcg at refrigerator storage. Room temperature storage of 90 days showed a beta carotene content in the range of 25 to 95 mcg in ragi based formulations and 30 to 105 mcg in wheat based formulations. The reduction in carotenes after storage might be due to the thermolabile and photosensitive nature, isomerisation and epoxide forming nature of carotenes (Charleux, 1996).

4. Calcium, Phosphorus and Iron Content

Table XVI shows the calcium, phosphorus and iron content of the fresh and stored nutritious mixes.

TABLE XVI

CALCIUM, PHOSPHORUS AND IRON CONTENT OF THE FRESH AND STORED NUTRITIOUS MIXES

(In 100g)

S.No.	Nutritious Mixes	Calcium (mg)			Phosphorus (mg)			Iron (mg)		
		Initial	After 90 days		Initial	After 90 days		Initial	After 90 days	
			Ref	RT		Ref	RT		Ref	RT
	PAPAYA POWDER									
1.	R_1(R+RBG+G+J+P)	111.5	110.0	110.2	22.80	230	227	5.4	5.4	5.3
2.	W_1(W+RBG+G+J+P)	46.7	46.5	46.6	165.0	166	164	5.0	5.0	4.9
	SAPOTA POWDER									
3.	R_3 (R+RBG+G+J+S)	113.1	113.0	113.1	230.0	232	228	5.6	5.6	5.4
4.	W_3(W+RBG+G+J+S)	48.1	48.0	48.0	170.0	172	169	5.2	5.2	5.0

Ref : Refrigerator RT : Room Temperature

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

There was a negligible reduction in the calcium content of papaya powder incorporated formulations (1.5 % to 2.2 mg %) compared to no change among sapota powder incorporated formulations after three months of storage.

In ragi and wheat based formulations the phosphorus content was slightly increased by two to three per cent when stored in the refrigerator whereas at room temperature the phosphorus content was reduced by one to two per cent.

The iron content of ragi and wheat based formulations was found to be same when stored in the refrigerator whereas at room temperature a slight decrease (0.1 to 0.2 mg %) in iron content was noticed.

5. Keeping Quality of the Nutritious Mixes after 90 Days of Storage

Table XVII shows the mean acceptability scores of the selected nutritious mixes after 90 days of storage.

TABLE XVII

MEAN ACCEPTABILITY SCORES OF RAGI AND WHEAT BASED NUTRITIOUS MIXES AFTER STORAGE

(In 100g)

S.No.	Nutritious Mixes	Appearance (5)	Colour (5)	Texture (5)	Flavour (5)	Taste (5)	Overall Acceptibility		
							stored sample (25)		Fresh sample (25)
							Ref	RT	
	PAPAYA POWDER								
1.	R_1(R+RGB+G+J+P)	4.0	5.0	5.0	3.0	3.7	20.70	20.65	20.8
2.	W_1(W+RGB+G+J+P)	4.35	5.0	4.35	3.7	4.0	21.40	21.30	21.4
	SAPOTA POWDER								
3.	R_3(R+RGB+G+J+S)	4.80	4.85	4.85	3.4	3.4	21.30	21.20	21.35
4.	W_3 (W+RGB+G+J+S)	4.35	5.0	4.35	3.7	4.5	21.90	21.80	21.90

R - Ragi; W - Wheat; RBG - Roasted Bengal Gram; GG - Green Gram; G - Ground nut; J - Jaggery; P - Papaya Powder; S - Sapota Powder

The mean scores of papaya and sapota incorporated ragi based nutritious mixes were 20.70, 21.30 in refrigerator and 20.60, 21.10 in room temperature and for the wheat based nutritious mixes the scores were 21.40, 21.90 in refrigerator and 21.00 and 21.30 respectively. The scores obtained for the stored nutritious mixes were similar to the scores obtained initially.

The stored ragi and wheat based nutritious mixes ranked in the same order as fresh samples and scores obtained were not much different from the initial scores. Even after three months of storage the nutritious mixes were found to be highly acceptable.

F. COST OF THE HIGHLY ACCEPTED NUTRITIOUS MIXES

The cost of the formulated highly accepted nutritious mixes calculated taking into account of the prevailing market prices is given in Table XVIII.

TABLE XVIII

COST OF THE HIGHLY ACCEPTED NUTRITIOUS MIXES

S.No.	Formula	Amount (g)		Cost (Rs.)	
		Ragi based	Wheat based	Ragi based Rs. P.	Wheat based Rs. P.
1.	Ragi	35	-	0·35	-
2.	Wheat	-	35.0	-	0.49
3.	Bengal gram dhal	22.5	22.5	0.72	0.72
4.	Jaggery	22.5	22.5	0.27	0.27
5.	Groundnut	10.0	10.0	0.30	0.30
6.	Papaya	10.0	10.0	0.24	0.24
7.	Sapota	-	-	0.47	0.47
	Total	100.0	100.0		
	Cost of				
	Papaya based			1.88	2.02
	Sapota based			2.11	2.25

The cost of papaya and sapota powders incorporated with ragi and wheat based formulations were calculated, and found that among the two formulations papaya incorporated ragi based formulations costed Rs. 1.88/100gms whereas sapota incorporated ragi based formulations costed Rs. 2.11/100gms. Similarly papaya incorporated wheat based formulations costed Rs. 2.02/100g, whereas sapota incorporated wheat based formulations costed Rs. 2.25/100gm.

These formulations are found to be inexpensive and have the advantage of providing more micronutrients in addition to calories and proteins, a food based strategy in the alleviation of micronutrient malnutrition.

Thus the results of the present investigation shows that it is possible to incorporate dried fruits in a cereal-pulse based weaning food, which could be processed by simple methods like drying and roasting and prepared at household level. Nutritive value of the formulated nutritious mixes were comparable to ISI specification. Among the nutritious mixes formulated sapota incorporated mixes were found to be more acceptable than papaya incorporated mixes. Shelf life studies of the highly acceptable roasted bengal gram and papaya / sapota incorporated ragi and wheat based formulations indicates that retention of nutrients were better or comparable. It is encouraging to note that the use of solar energy is no means detrimental to the nutritive content of the foods. Hence the formulated nutritious mixes could well be recommended for infants and preschoolers and needs to be popularized in the community, to alleviate the problem of micronutrient malnutrition.

SUMMARY AND CONCLUSION

V SUMMARY AND CONCLUSION

The present study entitled "Formulation and Evaluation of Nutritious Mixes Incorporated with Papaya and Sapota Powders" is aimed at developing low cost nutritious mixes using simple household processing methods.

Papaya is considered as a fruit of choice of the processing sector as the availability of the fruit is largely spread throughout the year. The comparatively cheaper cost of papaya, higher recovery of pulp, attractive colour of the flesh, high carotene content to alleviate vitamin A deficiency and suitability for a wide range of processed products make it more ideal for processing. Sapota is one of the prominent fruit which is sweet in taste and has a pleasant flavour with high nutritive value. In India, sapota is usually available in plenty when other common fruits go out of market. Taking these factors into consideration papaya and sapota were selected as the fruits for the study.

Papaya and sapota pieces were dried using sun, hot air oven and solar drying in order to preserve the fruits without loss of quality for extended periods. The dried fruits obtained were ground into fine powders separately.

The fruit powders were analysed for their nutrient content like energy, protein, carbohydrate, calcium, phosphorus, iron, thiamine, riboflavin, vitamin C, carotenes, reducing sugars and other parameters like ash, moisture and acidity and also subjected to acceptability trials.

The results obtained from nutritient analysis revealed that fruit powders obtained by solar drying were found to be best. These solar dried fruits were incorporated at 10 per cent level into four ragi based and four wheat based mixes. Acceptability trials were conducted for all the formulated nutritious mixes and their nutrient contents were also analysed. Four highly accepted mixes were taken for shelf life studies and analysed for their nutrient content. Acceptability trials were also conducted for the selected nutritious mixes at the end of the shelf life period. Finally the cost of the formulated nutritious mixes were calculated according to the prevailing prices of raw materials used.

The salient findings of the present study can be summarized as follows:

- Drying of papaya and sapota fruits showed that the time taken for sundrying and solar drying were found to be twice as that of hot air oven drying.

- Solar dried sapota powders were found to provide more energy with a value of 274 to 280 kcal per 100 g in comparison with solar dried papaya powders which contained only 181 to 189 kcal.

- Protein values were also slightly higher for solar dried samples. The carbohydrate values ranged from 32 to 34 g per cent for papaya powders and 38 to 42 g per cent for sapota powders, with solar dried samples showing the maximum carbohydrate content.

- Calcium, phosphorus and iron content of the papaya and sapota powders obtained by solar drying were found to be 29.0 mg and 43.0 mg, 36,8 mg and 61.0 mg and 0.9 mg and 2.62 mg per 100 g per cent respectively, which were found to be more than the sun dried and hot air oven dried samples.

- Among the three methods, solar dried papaya powders had 0.02 mg and 0.01 mg per cent of thiamine and riboflavin respectively whereas, sapota powder had 0.004 mg and 0.005 mg / 100 g being the highest values when compared to sun and hot air oven dried samples.

- Ascorbic acid is lost due to oxidation while drying to the extent of 75 per cent.

- Total and beta carotene contents of hot air oven dried papaya powder was 11.008 mg and 3.427 mg per 100 g being the highest compared to sundried and solar dried samples. Similarly, sapota powder of hot air oven drying contained 1.746 mg of total carotene and 0.540 mg of beta carotene per 100 g when compared to the lower values reported among the other two methods of drying.

- Other components like reducing sugars, acidity and total soluble solids (TSS) contents were retained to a maximum extent in solar drying compared to sun and hot air oven drying.

- Four ragi based and four wheat based formulations incorporated with papaya and sapota had an energy content ranging from 335-370 kcal and 340 to 375 kcal per cent respectively.

- Carbohydrate content was found to be more among sapota powder incorporated nutritious mixes (65 to 75.7%) than among samples with papaya powder incorporation (58.4 to 69%).

- The protein content of the papaya and sapota powder incorporated ragi based formulations ranged from 10.2 to 11.6 g and that of the wheat based formulations ranged from 11 to 11.82 g per cent.

- Ragi based nutritious mixes had moisture and ash contents ranging from 4.7 to 6.0 g and 2.1 to 2.21 g per cent respectively, whereas wheat based nutritious mixes had moisture and ash contents of 5.0 to 5.6 and 1.7 to 1.9 g per cent respectively.

- With regard to water soluble vitamins like thiamine and riboflavin, the ragi based formulations contained from 0.12 to 0.22 mg and 0.03 to 0.09 mg per 100 g respectively. Similarly wheat based formulations had thiamine and riboflavin contents ranging from 0.08 to 0.10 mg and 0 to 0.04 mg per cent respectively.

- All the formulated nutritious mixes with sapota incorporation had no ascorbic acid, whereas papaya incorporated nutritious mixes had very low amount with a value of 1.0 mg of ascorbic acid.

- The total carotene content of the papaya and sapota powder incorporated ragi based formulations were found to be in the range of 310 to 380 mcg per 100 g and 70 to 80 mcg / 100 g respectively. Whereas in wheat based formulations were found to be in the range of 315 to 390 mcg and 85 to 95 mcg / 100 g respectively.

- The beta carotene content of the papaya and sapota powder incorporated ragi based formulations ranged from 170 to 190 mcg / 100 g and 40 to 50 mcg / 100 g respectively. But wheat based formulations contained in the range of 200 to 210 mcg / 100g and 45 to 60 mcg / 100 g respectively being slightly higher than ragi based mixes.

- In general, all the ragi based papaya or sapota powder incorporated mixes had a maximum amount of calcium, phosphorus and iron compared to wheat based mixes.

- It is evident that sapota incorporated mixes had higher reducing sugar (19.1 to 24.2 grams per cent) than papaya added mixes (17.4 to 20.7g per cent) which may be attributed to the higher sweetness of sapota than papaya.

- Total Soluble Solids present in sapota based formulations were slightly higher in the range of 18.0 to 18.5^0 Brix compared to papaya based formulations where it was in the range of 17.4 to 17.9^{0}Brix.

- Acceptability trials indicated that ragi and wheat based nutritious mixes incorporated with roasted bengal gram with papaya and sapota powders (R_1, W_1, R_3 and W_3) ranked first with scores of 20.8, 21.4, 21.35 and 21.9 and those with green gram incorporated nutritious mixes ranked second with 19.78, 20.65, 21.05 and 20.50 scores out of a maximum score of 25.

- Shelf life studies showed that the energy, carbohydrate, protein, calcium, phosphorus, iron and moisture content slightly increased in refrigerated samples compared to room temperature stored samples.

- Thiamine, riboflavin and ascorbic acid content of ragi and wheat based formulations showed slight reduction when stored at room temperature.

- Carotene content of the ragi and wheat based formulations decreased slightly after 90 days of storage. This might be due to the oxidation of the samples on storage.

- Acceptability scores of ragi and wheat based nutritious mixes after storage showed that even after three months of storage the nutritious mixes were found to be highly acceptable.

- Papaya and sapota powders incorporated with ragi based formula tions costed Rs.1.88 for100 g and Rs.2.11 for100 g, whereas wheat based formulations costed Rs.2.02 for 100g and Rs.2.25 for 100 g respectively.

The present study revealed the feasibility of incorporation of dehydrated papaya and sapota powders in nutritious mixes to get more nutrients especially micronutrients. When the whole world targets at eliminating micronutrient malnutrition in developing countries, it is our responsibility to tap the locally available resources like papaya and sapota and enrich the nutritious formulations.

The following areas are suggested for future studies.

- Scope of incorporation of various types of solar dried fruits and into basic mixes and evaluation.
- Feasibility of vegetables incorporation into nutritious mixes.
- Long term studies on infants and preschool children fed with nutritious mixes incorporated with fruits with respect to micronutrient status.
- Formulation of beverage mixes based on fruits, vegetables, cereals and pulses to tackle the problems of protein, energy and micronutrient malnutrition.
- Studies on promotion and popularisation of nutritious mixes with fruits and vegetables at homescale levels in rural communities coupled with nutrition education.

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APPENDICES

APPENDIX I

SCORECARD FOR ACCEPTABILITY TRIALS

S.No	Criteria	Score
1.	**Appearance**	
	Excellent	5
	Very good	4
	Good	3
	Satisfactory	2
	Fair	1
2.	**Texture**	
	Fine Powder	5
	Coarse Powder	4
	Leathery	3
	Lumpy	2
	Granuels	1
3.	**Taste**	
	Excellent	5
	Verygood	4
	Good	3
	Satisfactory	2
	Poor	1
4.	**Flavour**	
	Excellent	5
	Verygood	4
	Good	3
	Satisfactory	2
	Poor	1
5.	**Colour**	
	Cream	5
	Pale yellow	4
	Pale brown	3
	Yellowish brown	2
	Dark brown	1

APPENDIX II

ESTIMATION OF TOTAL BETA CAROTENE

Principle

The high performance liquid chromatography is found to be the most reliable, efficient and reproducible method for carotenoid analysis. The carotenoids in foods are generally associated with the lipid fraction and hence beta carotene in the food is saponified with 12 per cent alcoholic potassium hydroxide and extracted with petroleum ether (60°C to 80°C), filtered and the carotenoid pigments separated, identified and estimated using reverse phase isocratic solvent system. Identification and quanification are based on the retention time and peak area of the individual samples.

Reagents

1. 12 per cent alcoholic potassium hydroxide
2. Petroleum ether (60°C to 80°C)
3. HPLC grade solvents - methanol, acetonitrile, dichloromethane
4. Calcium carbonate
5. Anhydrous sodium sulphate
6. Beta carotene standard (sigma, USA)

Procedure

1. 0.25g of the sample food was taken in a mortar and pestle added small amount of fine glass powder (1g) and macerated with a small amount of potassium hydroxide (12 per cent), so that the sample was completely immersed in it.

2. Transferred the ground sample into a conical flask and added the washings of the remaining sample in the mortar with 12 per cent potassium hydroxide.

3. Placed in a shaking water bath at 37°C for 30 minutes to saponify the contents.

4. Mixed the conical flask-contents with little calcium carbonate and petroleum ether (60°C to 80°C) using a vortex mixer.

5. Transferred the contents of the conical flask into a separating funnel.

6. The upper layer was collected, discarding the lower layer and repeatedly extracted with petroleum ether until a yellow colour was observed in the supernatant layer.

7. Filtered the extract through glass wool, over which anhydrous sodium sulphate was kept to remove any moisture.

8. Volume of the solution was taken in a cuvette and the opitical density was determined from which the total carotene is calculated.

Calculation

Weight of the sample =

Total volume =

Optical density (O.D) =

Total carotene = $\frac{\text{O.D.} \times 4 \times \text{volume} \times 100}{\text{Weight of the sample}}$ mcg in 100g

Determination of beta carotene by HPLC

One ml of the sample solution was filtered through 0.4 millimicron filter and 20 microlitres was used for quantification in High Performance Liquid Chromatography (HPLC).

The HPLC schimadzu model is equipped with a variable wavelength and integrator. The wavelength is set at 450nm. A stainless steel column 150 x 4.6 mm in diameter, pre-packed with shim-pack CLS ODS packing is use for carotenoid analysis. The solvent system, Acetonitrile: Dichloromethane: Methanol, all HPLC grade solvents (70:20:10) was pumped at a flow rate of 2 ml per minute. Beta carotene standards used are of sigma chemical company (USA) type IV synthetic from carrots.

An external standard was used for quantification. Because of variation in concentration of compounds to be analysed in the food matrix, no internal standard was used. The HPLC was calibrated daily by injecting full a loop (20 microlitres) of each standard solution in a duplicate or triplicate. Each sample was injected in duplicates and the concentration determined from the calibration plot in which peak area was plotted against concentration (mg/ml). The detector responses are linear over the concentration range of 25 to 100ng per 20 microlitres. All results were expressed as microlitres per gram of fresh weight of the food stuff. Peak identification was based on the retention times and comparison with standards and co-chromatography with the standards.