CHANGES IN COOKING QUALITIES, NUTRITIONAL COMPOSITION AND SHELF LIFE OF SWEET POTATO STORED UNDER DIFFERENT METHODS

By

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THESIS

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1994

DECLARATION

I hereby declare that this thesis entitled **"Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods**"is a record of research work done independently by Kum. SEEMA THAMPI. S, under my guidance and supervision and that it has not previously formed the basis for the award of any degree,diploma, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

In the struggle for human survival, tuber crops are gaining importance day by day as a source of food. Tuber crops are the third most important food crop and about one-fifth of the world's population depend on these crops as their staple or main supplementary food. Among the root and tuber crops, sweet potato (<u>Ipomoea batatas</u>. L.) holds the third and important position after potato and cassava in South Asia.

It is believed that sweet potato was domesticated in the Peruvian coast of South America about 10,000 years ago, in the Neolithic period, perhaps in the late Ice Age on 3000 B.C. Roughly 80 per cent of the world's sweet potatoes are now grown in Asia. It occupies an area of about 9.3 million hectares spread over more than one hundred countries and produces about 135 million tonnes of tubers (Anon., 1987). China occupies the first place in yield and production in the world with an annual production of 90 million tonnes (Upadhya, 1990).

In India, sweet potato is grown throughout the country occupying an area of about 158 thousand hectares with a production of about 1279 thousand tonnes (Anon.,1989). More than 70 per cent of the total area of production of sweet potato in India is found in three states namely, Orissa (28.3 per cent), Bihar (24.4 per cent) and Uttar Pradesh (19.3 per cent) (Thankappan and Nair, 1990, and Vimala, 1990). The annual production of sweet potato in Kerala is 19951 tonnes from an area of 2457 hectares (Anon., 1994).

Sweet potato is undeniably one of the world's most important food crops due to its high yield potential and nutritive value. In addition to starch, the tuber flesh contains various sugars, minerals and protein with all essential amino acids. The tuber also contains sufficient amount of carotene and is rich in thiamine. Besides its use as a human staple, its importance in preparation of processed products in bakeries and industries is increasing .

Unlike cassava, sweet potato tuber can be cultivated in certain specific seasons only. The perishability of the tuber limits its post harvest utilisation throughout the year. So, in order to ensure a continuous supply of the tuber throughout the year, it is necessary to find out suitable storage techniques for preventing deterioration and damage of the tubers. It also ensures the farmer a steady and reasonable price for the produce.

Most of the present methods of storage cause deteriorative changes which may considerably affect its quality for consumption or industrial use. So it is highly necessary to devise suitable techniques for satisfactory storage of sweet potato without causing deterioration of the quality. Though, some basic preliminary studies have been carried out in this field, much is yet to be done to find out a satisfactory solution for the storage problem of sweet potato tuber in the State.

Hence, the present study is attempted to find out simple, viable and economically feasible storage methods of sweet potato using locally available materials based on changes in cooking, organoleptic and nutritional qualities during storage.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Informations available on different aspects related to the present investigation on "Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods" have been briefly reviewed under the following headings:

2.1 Importance of sweet potato as a food crop.

2.2 Nutritional and commercial significance of sweet potato.

2.3 Storage and shelf life of tubers.

2.4 Qualitative characters of fresh and stored tubers.

South America has been widely recognised as the centre of origin of sweet potato. Jos (1990) opined that the crop have been introduced in India by the Portugese in the early sixteenth century. Rajendran (1990) detected different varieties of sweet potato, including eleven wild species. Cultivated species of sweet potato; botanically known as <u>Ipomoea batatas</u> L., belongs to the family Convolvulaceae.

2.1 Importance of sweet potato as a food crop

Sweet potato has remained for centuries, as an important staple for many tropical countries(Onwueme, 1978). Among the roots and tubers, sweet potato is one of the highest yielding crops and has been cultivated as an important source of food in many countries (Kabeerathumma,1990). Ramanathan et al. (1990) defined tuber crops as the third most important food crop and assumed that about one-fifth of the world's population depend on this crop as their staple or main supplementary food. Moorthy and Padmaja (1990) proclaimed that the tubers occupy a prominant place in the diets of people in many humid tropical regions. Pillai (1990) has expressed that sweet potato occupies the second and most important place in the tropics next to cassava, as a food crop. In the world production, sweet potato ranks eighth and holds the seventh place in the area harvested (Anon.,1991).

Jairth et al. (1990) have observed that the cultivation of sweet potato is spread widely in all states of India. Vimala (1990) estimated the production of sweet potato in India to be almost 50 per cent of the Asian average. This is much lower than the average world productivity (Pillai et al. 1992).

2.2 Nutritional and Commercial Significance of sweet potato

According to Dayal (1990), sweet potato plays a very important role as the survival food because of its high nutritive value and greater energy production. Tsou and Hang (1992) observed sweet potato as a low cost food, rich in food energy, dietary fibre, minerals and vitamins.

Maini (1976) considers that the most important constituent of sweet potato in which the quality is judged is its sugar content. Ghosh et al. (1988) judged sucrose as the major sugar present in sweet potato with minor quantites of reducing sugars. Lila (1988) and Lila and Nambisan (1990) found that the percentage of reducing sugars constitute 0.85 to 6 per cent of tuber dry weight.

Moorthy and Balagopal (1985) emphasized starch as the major food reserve in the tubers. The starch varies from 50 to 75 per cent on dry weight basis in different cultivars of sweet potato (Lila _et al_ ., 1990).

Onwueme (1978) ascertained that the moisture content in sweet potato, ranged from 50 to 81 per cent. Woolfe (1988) upheld sweet potato as superior source of B - complex vitamins and ascorbic acid content.

Lila (1985) opined that the varying colour of tuber flesh from white to dark orange is depending upon the amount of carotene present. Woolfe (1988) and Jos _et al_.(1990) also believed that the dark orange flesh colour of tubers is associated with the high carotene content. The range of carotene in sweet potato cultivar is very wide. Goswami (1990) reported that the carotene content ranged from 0.3 to 7.2 per cent in different genotypes. The orange fleshed variety of sweet potato have been widely admitted as an excellent source of the provitamin A - beta carotene (Anon.,1992 and Tsou and Hang,1992).

Grant *et al*.(1992) detected phosphorous and potassium as the major minerals present in sweet potato tubers; with modest amounts of iron, magnesium, calcium, copper. The authors found that the tubers contain almost all essential amino acids except some sulphur containing amino acids.

Lu *et al*. (1986) pointed out the rich sources of ascorbic acid in sweet potato tubers. Woolfe (1988) concluded that 100 grams of sweet potato per day can supply a significant part of daily nutrient requirements for a man.

One of the minor draw back reported in sweet potato is the occurance of flatulence, which resulted in low protein digestability by the stomach, due to a bulky or prolonged intake of uncooked tubers. Padmaja (1985) reported the presence of trypsin inhibitors in all tuber crops. Tsou *et al*.(1988) suspected that the trypsin inhibitors in sweet potato is responsible for the low protein digestability. The authors advised proper cooking of tuber to overcome this disadvantage. However, certain protective effects of sweet potato have been reported by some workers. Hill et al.(1992) claimed that the presence of auto oxidant nutrients such as beta carotene, ascorbic acid and tocopherol in sweet potato could be able to act against heart diseases and cancer in humans. It is well known that the tuber contained varying amount of fibre content. Kays (1992) believed that the fibre content in sweet potato is having the capability to decrease the blood cholesterol levels by daily use. Therefore, sweet potato can be considered as a natural health food also.

Nair (1976) revealed that the sweet potato starch is suitable for sizing paper and textiles, in laundries and in manufacture of adhesives, dextrins, cosmetics and for many other purposes. Collins and Hutsell (1987) prepared a vegetable leather from sweet potato mixed with apple.

Vimala Kumari et al.(1980) formulated recipes for cassava based food products. Similarly, a number of speciality products like baby foods, snacks, candies, sauces, crackers, breakfast foods and reconstituted chips have also been developed by Moorthy (1990). Padmaja et al. (1991) also developed different new recipes from sweet potatoes, including fruit salad, sherbet, cake, jellies, gulab jamun, sukhiyan, puddings. Thirumaran and Ravindran (1992) reported the processing technique of sweet potato vermicelli. The authors prepared various products like stew, foodmix, payasam, laddu, halwa and many other items using sweet potato. Chellammal and Prema (1993) standardised extruded food products such as macaroni, using sweet potato flour. Gregory (1993) stated sweet potato as the most versatile of all the major root and tuber crops.

Aside from being the potential food of the future, sweet potato is a potential substitute for wheat and corn as source of flour. Nayar and Rajendran (1988) pointed out the utility of dried and powdered sweet potato chips as supplement to cereal flours in bakery products. As wheat flour substitute, sweet potato can replace 10 to

20 per cent of the flour mix (Anon.,1991). Woolfe (1992-b) assessed that sweet potato flour replaces the use of wheat upto 50 per cent in Peru. The technology for processing sweet potato for making chips has been successfully developed by Data and Opario (1992).

Zosima (1992) opined that, since the price of sweet potato is several times cheaper than wheat flour, it could be used as a substitute to wheat flour in bread making also. Ono and Hirano (1992) noticed that in Southern China, sweet potato is usually steamed, boiled or baked and there is little variety in preparation. But in some other parts of China, large industries have been developed and sweet potato is utilised for the production of noodles, baby foods, candies, pies and a range of other products. Balagopal et al.(1993) extracted the industrial starch from sweet potato using enzymatic treatments. The authors believed this attempt as an asset for new avenues in the industrial utilisation of sweet potato starch in the future.

2.3 Storage and shelf life of tubers

Kushman and Wright (1969) hypothesise that, as sweet potato is having an important place in the human diets, storage of the tubers benefits both the producer and the consumer by making them available throughout the year. Bouwkamp (1985) and Data and Eronico (1987) found that the tubers after harvest are perishable and metabolically active and hence their storage is much tedious. However, sweet potato storage has not attracted much attention in India, where most of the tubers are consumed within a few days after harvest (Ghosh et al. 1988). Padmaja (1990) reported that the sweet potato tubers cannot be normally stored for more than one month without deterioration in its nutritional quality. Therefore, some post harvest treatments are usually needed to apply on tubers, which helps to improve the storage life.

2.3.1 Pretreatments and their outcomes

Certain pretreatments like curing and chemical dipping were usually applied to the tubers to get better results during storage.

Chacko (1976) advocated that proper curing of the sweet potato before storage aid in assuring good market quality, as exemplified by good appearance, desirable culinary quality and freedom from defects. Bouwkamp (1985) believed that, sites of injuries are ideal invasion points of pathogens. Curing minimises the microbial attack of tubers while storage, by promoting rapid healing of the wounds occured during harvesting and handling (Ghosh et al., 1988). Studies conducted by Rickard and Poulter (1990) and Mehta and Kaul (1993) revealed that formation of wound barrier minimises water loss and oxygen entry to the tissues and further reduces physiological deterioration.

Siki (1979) illustrated the method for curing practised in Papua, New Guinea. The sweet potato tubers are placed on platforms in the house, in a dark, well ventilated area where heat or smoke from the cooking fire appears to aid curing of tubers. Balagopal and Moorthy (1984) and Lancaster and Coursey (1984) recommended a temperature range of 45 to 50°c and a relative humidity of 85 per cent for three to four days for curing of cassava tubers. Padmaja (1990) proposed that better curing can be achieved by placing tubers in plastic lined crates and providing sufficient conditions of temperature and relative humidity inside these crates. But, for storage of tubers in the Indian climatic conditions normally, artificial curing of sweet potato is not necessary. Woolfe (1992-a) observed that natural wound healing takes place in sweet potato at a fairly rapid rate under ambient conditions.

Several chemical treatments have been explored to reduce storage sprouting of sweet potato; although, some may increase the respiration rate (Onwueme,1978). Nair and Ramanujam (1982) found that maleic hydrazide treatment is effective in controlling storage sprouting in yams. Storage studies conducted by Padmaja and Rajamma (1982); Doreyappa and Krishnappa (1985) and Rama and

Narasimham (1985) revealed that chemical treatments were effective to prevent storage sprouting of potato upto sixtieth and seventy fifth day of harvest; but no effect was observed in physiological loss in weight. According to Thampan (1979), fumigating cassava tubers with a mixture of ethylene and methylene bromide has been found effective to extend the storage life beyond three weeks. Nathan et al. (1980) reported the capability of chemical treatments in preventing access of micro organisms. Shashirekha and Narasimham (1986) investigated the effectiveness of mercurial compounds and synthetic dyes against potato spoilage and sprouting. The results indicated that synthetic dyes were more effective against microbes compared to mercuric compounds. Nwufo (1988) from his studies concluded that storage rots can be reduced considerably by dipping colocasia corms in Benlate and Captan before storing in different media such as moist sawdust, soilpit and polythene bag. But these fungicidal treatments had no effect on sprouting and weightloss of the corms. Best et al. (1990) recommended antimicrobial spray on cassava tubers prior to storage in polyethylene bags to prevent microbial decay. Rickard and Poulter (1990) revealed that treating cassava roots with fungicides and placing them in polyethylene bags, reduce spoilage of tubers for three weeks. The findings of Kumar et al. (1993) reflects the usefulness of chloropropham dusting for a better keeping quality of potato in evaporatively cooled storage.

Padmaja and Rajamma (1982) reported that the application of insecticide mixtures on storage media such as sand and red earth were found effective in preventing weevil damage of sweet potato. The study also indicated that the storage of tubers in gunny bags with insecticide treatments could resist weevil attack for one month. Fumigation of fungicides on storage media such as sand and red earth prior to storage also prevented weevil incidence (Pillai, 1990).

2.3.2 Common storage techniques practised for tubers

A report of Villanueva (1979) and Hrishi and

Balagopal (1979) indicated that the sweet potato tubers are often stored for short periods of two or three weeks before use. George (1987) pointed out that the storage conditions are of prime importance, whether short or longer terms of storage is to be made possible.

2.3.2.1 Ancient practices followed for storage of tubers

As early as 1943, Blyth elicited the practice of pit storage of sweet potato tubers with alternate layers of wood ash, in Zimbabwe. The same was carried out in New Guineau, with alternate layers of grass in grasslined pits (Anon., 1949). According to Onwueme (1978), one of the oldest methods of storage of sweet potato was keeping the harvested tubers in underground pits covered with grass. Keeping in ordinary baskets at ambient temparature was also practised in the households. But Bouwkamp (1985) denied the ground storage of tubers, since it is hazardous and having greater chances of being attacked by beetles and termites present in the soil.

Booth (1973) suggested the clamp method for storage of cassava to keep the roots undeteriorated upto two weeks. Later in 1980, Aiyer et al. also found that practising the clamp method for storage of cassava by placing cassava leaves as interlayering material, tubers can be preserved for a period of seventeen to twenty eight days with lesser damage. Padmaja (1990) listed out some of the storage methods namely "ondol" storage and "tunnel" storage which were practised in Korea.

Rajamma (1984) expressed that the usual practice of storage by keeping the harvested tubers exposed in the gowdown is not advisable, as it leads to heavy damage due to weevil attack by one month. James (1985) suggested the method of storing cassava by packing the roots in wooden boxes filled with layers of moist saw dust to overcome the difficulties of clamp method and underground storage.

Manwan and Dimyati (1988) revealed the storage practices by commercial farmers in Java. They usually keep the harvested tubers for 1 to 3 days before marketing in cemented or uncemented floor, wooden or bamboo benches, piled under the bench or put into bamboo containers. Siddique and Rashid (1988) found that in Bangladesh, the sweet potato tubers were seldom stored for longer periods. For shorter durations less than 3 months, the tubers were kept in bamboo made containers. Sometimes, sand or wood ash is layered in between the tubers. The ancient practice of storage of sweet potato inside small huts made of bamboo and coconut fronds can effectively improve the shelf life for 2 to 3 months (Anon.,1991).

2.3.2.2 Low temperature storage of tubers

Refrigerated storage has been widely used for fruits and vegetables in many countries. Patra and Sadhu (1992) found it very effective to store litchi fruits at 10°c to prolong shelf life as well as to prevent vitamin losses. Jijiamma and Prema (1993) reported refrigeration as the best method for storage of amaranthus. But for roots and tubers the freezing temperature is not at all common.

Onwueme (1978) suggested the temperature range from 13 to 16°c for refrigerator storage of tubers; which is sufficient in the tropical conditions. But, Hameed _et al_. (1980) and James (1985) adduce the limited applicability of refrigeration storage of tubers, regarding the highly expensive nature of the technique, that cannot be afforded by the local farmers. Mehta and Kaul (1987) obtained satisfactory results using an evaporatively cooled structure which maintains the temperature at 2 to 4°c and relative humidity of 95 per cent, when potato tubers were stored for 12 weeks with less physiological losses.

2.3.2.3 Irradiation for storage of tubers

Key (1973) suggested the irradiation treatment on tubers, before storage to inhibit the sprout growth. Data and Barcelon (1985) claimed that pathogen entry can be hindered by keeping the sweet potato roots in storage huts using diffused light. Lu _et al_. (1989) noticed an increase in nutrient content of stored sweet potato, as a result of the irradiation treatment.

2.3.2.4 Waxing and mud coating of tubers

Covering over the exposed outer skin of tubers with a thick solid material is supposed to be effective in enhancing the life of the stored material. In the early 1943, Castagnino tried this method in Argentina for storing tubers using a paraffin wax coating and got favourable results. Keeping this in veiw, Subramanyan and Mathur (1956) suggested a fungicidal wax coating on cassava to store upto 2 weeks. Salazarda (1973) obtained best results with paraffin wax treatment on cassava storage. But Thompson et al. (1973) reported that waxing had no effect on the levels of fungal infection, even though the weight loss was consistant.

Mud coating of tubers is one of the most economic method and is an effective measure for the improvement of shelflife (Anon., 1983, Balagopal and Moorthy, 1984 and Ghosh et al. 1988).

2.3.2.5 Polythene covering for storage of tubers

Polythene covering is known to enhance the shelf life of fruits. Angadi and Shantha (1992) recorded successful results in limiting weight loss of coorg mandarin orange; Similarly Joshua and Sathiamoorthy (1993) registered superior results in sapota fruits stored in ventilated polythene bags; since there was lesser weightloss regardless of the higher decay incidence.

Storage of roots and tubers inside polythene covers has been suggested by many workers. Thompson *et al*. (1973) concluded that storage of yams inside airtight polyethylene bag is not preferable. They found that eventhough weightloss was minimum when compared to waxing; higher accumulation of humidity inside the sealed bags initiated greater incidence of mould growth on the tuber. Ghosh *et al*. (1988) magnified the effect of polythene covering in preventing water loss from stored tubers. Nwufo (1988) tried pierced polythene bags for the storage of colocasia corms, inorder to lessen the accumulation of humidity inside the covers. The author noticed that 85 per cent of fresh weight of the tuber was maintained upto 12 weeks of storage. The weight retention was superior in this treatment, compared to soil pit, dry and moist saw dust. Best et al. (1990) recommended the storage of cassava in polyethylene bags, after proper microbial treatment to prevent the microbial entrance. Data and Oparjo (1992) evaluated the effect of polythene sacks for the storage of dried sweet potato chips. The authors concluded the efficiency of polythene covers in preventing moisture penetration.

2.3.2.6 Storage of tubers using indigenous materials

Pillai et al . (1970) reported the effectiveness of saw dust for long term storage of tubers. According to Thampan (1979), cassava tubers could kept for four weeks when stored in moist saw dust inside boxes. Padmaja and Rajamma (1982) found that dry saw dust was unable to prevent dehydration of sweet potato beyond one month of storage. Balagopal and Moorthy (1984) stressed that the presence of moisture content in the media used for storage is a preventive factor against dehydration of tubers and spoilage thereby. James (1985) emphasized the benefical effect stating that the moisture content of the media provided a humid environment which helped to prevent dehydration of the stored tubers. The author proved the efficacy of moist saw dust for storage of cassava tubers. Padmaja (1985) observed that cassava tuber can be stored upto 75 days with less damage in saw dust having a moisture content of 20 per cent. Nwufo (1988) found that colocasia corms stored in moist saw dust was having lesser weightloss when compared with that of in dry saw dust and those kept exposed as control. Moist sawdust can be used to store both cassava and sweet potato for about 3 to 4 months (Anon.,1991). Mukhopadhya et al. (1991) also advocated sawdust as a good storage media to protect sweet potato from damage upto one month.

According to Marriot et al. (1974), cassava tubers packed in moist coir dust immediately after harvest at ambient temperature, remained sound for 28 days.

Thampan (1979) also observed the same result for cassava tubers when stored in moist coir dust. Therefore, the effectiveness of moist coir dust in storing other tubers have to be tried.

Booth (1977) found that cassava tubers were affected by rapid decay, when stored in moistened rice husk. Thampan (1979) insisted that the moisture content of the packing material should be at high level. Storage studies conducted by Marcelo and Arsenio (1988) revealed that taro corm can be stored beyond its usual storage life of 14 days by using rice hull ash, providing 40 to 45 per cent moisture content in the media. Mukhopadhya et al. (1991) postulated wood ash as an effective media to protect stored sweet potato from damage upto 30 days.

A study on large scale storage of cassava tubers conducted by Pillai and Nathan (1969) proved the beneficial effects of cassava leaf. The results revealed that as much as 68 per cent of tubers could be preserved using cassava leaf for a duration of 28 days. Aiyer et al. (1980) indicated that cassava leaves at the time of harvest is sufficient to store about 30 to 40 per cent of the harvested roots. Further, cassava leaves were found to be superior to other packing media such as water hyacinth, salvinia and eupatorium for storage of cassava tubers upto 10 days (Prema and Chellammal,1986).

Pillai <u>et al.</u> (1970) studied the effect of storing fresh cassava tuber in media such as moist laterite soil and coarse and fine sand. The results concluded that the tuber could be preserved upto 75 days with lesser damage, when the moisture content of the media was adjusted to about 20 per cent .

Balagopal and Padmaja (1985) reported that cassava tubers can be stored upto one and a half months in pits covered with moist sand/soil providing a moisture content of 15 to 20 per cent on the media. Cassava can be stored upto 75 days with less damage by adjusting the moisture content upto 20 per cent in media such as moist laterite soil and fine sand (Padmaja, 1985). Prema and Chellammal (1986) also investigated the effectiveness of storing cassava tubers in different depths of soil column. From the results, it is evident that the depth of one foot to two feet was better than half foot depth of soil column in various aspects assessed. Dayal et al. (1990) reported better results in sweet potato stored under sand; compared to those kept in ambient conditions. Moist sand can be used to store both cassava and sweet potato for about 3 to 4 months (Anon.,1991). The report makes it evident that cassava tubers can be stored upto 3 months by using soil as media for storage. Mukhopadhya et al. (1991) opined that white sand could protect sweet potato from damage upto one month. Further in a comparative study, the authors found local earth as a superior storage medium for sweet potato than red earth, earthern pot and exposed tubers. The authors again highlighted that good conditions can be maintained by storage of sweet potato using waste carbon paper for a prolonged duration. Among the storage methods tried for dried sweet potato chips, Data and Opario (1992) noticed jute sacks with moderately good effect; whereas open crates and straw sacks were not advisable, since it gave poor results on storage.

2.3.3 Problems and effects on storage of tubers

Highlighting the importance of storage conditions, Nayar and Rajendran (1988) reported that the primary purpose of storage conditions is to minimize pathological and physiological losses such as insect attack, weight loss, decay, sprouting, dehydration and chilling. However, sweet potato roots are perishable staples, it remains metabolically active after harvest, resulting in weight loss, shrivelling, decay and sprouting irrespective of the storage period (Siddique and Rashid, 1988). The authors observed that insect damage, rots and sprouting were the common causes of sweet potato spoilage during storage in Bangladesh.

2.3.3.1 Weevil damage of stored tubers

Balagopal and Moorthy (1984) reported that the only serious storage pest of sweet potato in India is the sweet potato weevil, <u>Cylas formicarus</u> Fab. Lu <u>et al</u>. (1988) found this weevil as the most important insect pest of sweet potato in China, while Siddique and Rashid (1986) observed sweet potato weevil as a serious storage pest in Bangladesh. Rajamma and Pillai (1990) stated that the damage caused by sweet potato weevil is very severe, giving an unpleasant odour to the attacked tubers. Bhat (1991) pointed out the decreased marketability of tubers caused by weevil damage. In general the losses caused by weevil infestaton is very substantial during storage of sweet potato (Anon.,1992).

Balagopal and Moorthy (1984) ascertained that the stored tubers are attracted by weevil due to the increased sugar content of the tuber by storage. As reviewed by Padmaja (1985), insects as well as rodents bring about considerable damage to stored tubers.

Prasad <u>et al</u>. (1981) noticed weevil incidence on sweet potato from second week onwards. The authors found that the loss due to weevil damage increased with the period of storage. Ghosh _et al_. (1988) suggested the storage of sweet potato, by heaping the tubers on the floor and covering them with red earth or wood ash, to protect the tubers from weevil attack upto two months storage. Certain volatile components present in sweet potato roots were known to have a capacity to deter the insects to a specific level. Starr _et al_. (1991) listed out several such constituents present in the sweet potato.

2.3.3.2 Weight loss of stored tubers.

Major reason for weightloss in sweet potato is the evaporation of moisture through the skin. Kushman and Wright (1969) consider that besides evaporation, sweet potato loses its weight as a result of respiration of tuber also. The authors defined respiration as a process that consumes the stored food in the roots and gives off carbondioxide and water; thereby decreasing the tuber weight. According to Bouwkamp (1985), since the roots are living organisms and remain metabolically active after harvest, respiration continues and water loss occurs during storage. Joshua and Sathiamoorthy (1993) correlated the lesser physiological loss in weight of sapota with decreased rates of respiration and moisture loss. Rangavalli _et al_. (1993) also revealed a close relationship between loss of fruit weight and respiration rate in mango. Kang and Gopal (1993) noticed a linear trend between the period of storage and weight loss of potato. However the weight loss was some what slower in the initial period of observations, it showed a gradual rise by ongoing storage. The authors again pointed out that the rottage of tubers is a significant contributer to weight loss.

Padmaja and Rajamma (1982) viewed that the sweet potato stored in dry saw dust and sand affected greater weightloss due to dehydration. Balagopal and Padmaja (1985) believe that loss in weight of stored tubers due to dehydration can be prevented by providing a moist environment in the medium for storage. Padmaja (1985) proved that dehydration of cassava tubers during storage can be prevented by adjusting the moisture content at about 20 per cent in the storage media such as saw dust, sand and soil. Mukhopadhya <u>et al</u>. (1991) in an investigation conducted on sweet potato storage found that the weight loss was more pronounced in exposed tubers, kept under red earth and in earthen pot, than tubers stored using waste carbon paper, local earth, saw dust, wood ash and white sand which could maintain 20 to 50 per cent weight even upto 90 days. In their comparative study, the authors concluded that waste carbon paper is more effective in checking the weight loss to a greater extent.

Dayal and Sharma (1987) revealed that storage at high temperature or at a high relative humidity level leads to greater weight loss in stored potatoes. Mehta and Kaul (1987) stored potatoes at evaporatively cooled structures; in which the temperature was provided at 2 to 4°c and the relative humidity was at 95 per cent. The results indicated that the weight loss was reduced to 1 per cent per month of storage. Mozie (1988) observed that yam tubers stored at 16°c had less weight loss during a period of 9 months than tubers from the same source stored at 10°c and 30°c which showed significant loss of weight. Dayal et al. (1990) reported that the respiration rate is directly related to the temperature and the weight loss. He suggested the sand storage for sweet potato; since it was believed to be effective to limit the supply of oxygen, and thereby the weight loss was found lowered to 11 percent for a period of 90 day storage. Ajayi and Madueke (1990) proclaimed that higher ventilation levels of the storage structures for yam leads to greater weight loss.

According to Mozie (1984) the rate of respiration of yam, showed a climateric rise on certain months of storage. Data and Eronico (1987) opined that the rate of storage losses and ability of sweet potato to resist such losses during storage varies according to different cultivars and hybrids. Bhandal and Naik (1991) proved that the maximum loss of weight of two varieties of potato stored using similar method of storage showed significant differences.

2.3.3.3 Decay of stored tubers caused by rotting

Key (1973) expressed that storage losses due to diseases can be very substantial which is often a serious problem in the tropics. Certain types of rots affecting sweet potato while storage as listed by Chacko (1976) are soft rot, black rot and dry rot. Onwueme (1978) believed fungal diseases caused by Rhizopus and Fusarium species as serious post harvest diseases of sweet potato. Padmaja (1985) pointed out black rot caused by Ceratocystis fimbriata and soft rot caused by Rhizopus stolonifer, results in considerable damage on stored tubers. Lu et al. (1988) reported the soft rot caused by Rhizopus spp. as an important storage disease; followed by black rot, in China. Various bacteria and fungi are responsible for the significant storage losses in sweet potato (Anon., 1992). Clark (1993) identified some important post harvest diseases of sweet potato. It include Rhizopus soft rot (caused by Rhizopus stolonifer or Rhizopus spp.), Java black rot (Bortryodiplodia theobromae), Fusarium root rot (Fusarium solani), Bacterial root rot (Erwinia chrysanthum) and Black rot in which Ceratocystis fimbriata is the causative organism. Ray et al. (1993) isolated several fungi affecting sweet potatoes under ambient temperature (30° ± 2°c) and relative humidity (70 to 95 per cent) of storage such as Rhizopus, Aspergillus, Fusarium, Penicillium and Botryodiplodia.

Moderately high temperature and relative humidity indicates the development of fungal diseases which leads to the decay of sweet potato (Anon., 1959). Kushman and Wright (1969) found that the development of decay is usually more rapid at high temperature than at 55° to 69°F. Thompson et al. (1973) detected higher levels of fungal infection in cold stored yam tubers which were kept inside sealed polyethylene covers. Padmaja (1990) opined that the low chances of ventilation often leads to great losses due to decay of stored tubers.

Padmaja et al. (1980) revealed that the secondary deterioration in cassava is caused by invading pathogenic organisms. Prasad _et al_. (1981) recorded tuber loss due to rot during the first week of storage of sweet potato. They further traced that, the rot was initially confined to damaged tubers alone; whereas in undamaged tubers, signs of rot was observed on the second week. According to Bouwkamp (1985), the roots that are bruised or injured during harvest are metabolically more active than unbruised roots and more likely to show susceptibility to invading pathogens. Balagopal and Padmaja (1985) postulated _Rhizopus oryzae_ as one of the spoilage organisms which affects the damaged tubers while storage. Rama and Narasimha (1985) observed that there was no significant difference between spoilage of chemically treated tubers and vapour heat treated tubers. For delaying decay in polythene covered cassava, Rickard and Poulter (1990) advocated certain fungicidal treatments on tubers before storing.

Marcelo and Arsenio (1988) found moist rice hull ash as a better storage medium for taro corms. Authors noticed that the decay incidence of taro corms after 60 days storage in moist rice hull ash was lowest at 54.81 per cent.

According to Data and Eronico (1987) certain tubers have a resistance to storage decay to a particular level. But this was found varied depending on their hybrids and species.

2.3.3.4 Incidence of sprouts on stored tubers

Adesuyi (1973) defined sprouting as a process that causes the translocation of nutrients from the tuber into the sprouts, which increases respiration, moisture and weightlosses, thereby reduces the palatability of the tubers. Bouwkamp (1985) and Padmaja (1985) observed sprouting as one of the main causes of storage losses in yam as well as sweet potato which even affects the quality of tubers. George (1987) mentioned that the tolerance to high temperature without undue loss and premature sprouting is vitally important for successful low cost storage in the tropics. Padmaja (1990) pointed out that the formation of non-edible sprouts considerably alters the edible quality of tubers and it also enhances the pithiness of tubers. Lila and Nambisan (1991) detected that sprouting also cause a decrease in starch and reducing sugar of stored sweet potatoes.

Kushman and Wright (1969) hypothesize that the sprout growth can occur at any time when temparature in the storage room rises above 60°F (15.5°c). The authors viewed that when there is high relative humidity, along with a high temperature, the heat and moisture gets collected in the top of the storage house, which also leads to sprouting of stored tubers. Dayal and Sharma (1987) observed a rapid sprout incidence at higher humidity levels. Mehta and Kaul (1987) noticed more vigorous sprouting on potatoes kept in evaporatively cooled store, though other qualities of tuber were satisfactory by this storage method. Mozie (1988) found that yams stored at 30°c showed higher incidence of sprouting than those kept at 16°c which remained un-sprouted throughout the longer storage period. Bhatia _et al_. (1991) stressed that higher humidity levels along with a moist environment is very much conducive to sprout growth.

Various sprout inhibitors have been used by many workers. Rama and Narasimham (1985) found that the efficiency of sprout inhibitors increased or decreased according to the increase or decrease in storage temparature and type of anti-sprouts used. Data and Eronico (1987) opined that the process of sprouting also depends upon the hybrid of sweet potato taken for storage. Dayal and Sharma (1987) surmised that the formation of internal sprouts might take place during prolonged storage, even when sprouts suppresants were used. Chauhan and Joseph (1987) advised that the preharvest foliar spray of certain sprout inhibitors were effective for delaying sprouts in long term post harvest storage of potatoes. Kaul and Mehta (1993) in an investigation of cured potatoes, noticed that sprouting was started from thirty days of storage in some hybrids and by 120 days, cent per cent sprouting was observed in all hybrids stored.

Nwufo (1988) indicated that the incidence of sprouting was more when stored under moist saw dust and pierced polythene bags when compared to dry saw dust and open storage. Ajayi and Madueke (1990) revealed that higher ventilation levels of storage delays sprouting of yams. Bhatia et al. (1991) pointed out that significantly high number of sprouts developed on tubers kept under moist sand, when compared to those kept under dry conditions.

2.3.3.5 Other physical changes leading to deterioration of stored tubers

Padmaja and Rajamma (1982) observed that sweet potatoes kept exposed in the open conditions suffered from maximum dehydration, after the first month of storage. Padmaja (1985) identified that the loss of moisture content is the reason for dehydration of stored tubers. Balagopal and Padmaja (1985) and Ghosh et al. (1988) convinced that by providing moisture content in the storage media, dehydration can be prevented to a specific level.

But, Data and Eronico (1987) mentioned that the perishable nature of sweet potato defenitely makes the tubers to shrivell fastly, even if the storage period is very short. Bouwkamp (1985) proclaimed that losses due to shrivelling, pithiness and other damages can be minimised by placing healthy and disease-free tubers for storage. Padmaja (1990) explained pithiness as an improportionate change in volume and weight of tuber, which gradually leads to increase the intercellular spaces called pith formation. Pithiness resulted to low culinary quality of tubers.

Kushman and Wright (1969) recommended well furnished storage houses with proper cleanliness and disease-free, unbruised tubers for storage, to obtain satisfactory results. The authors also suggested better curing conditions to prevent chilling injuries or desiccation of tubers. Chilling injury is a problem associated with storage of tubers at significantly low temperatures. Onwueme (1978) reported this problem in tubers stored below 10°c, resulting in internal breakdown of the tissues. Mozie (1988) observed chilling injury in tubers stored at 10°c, characterised by watery rot, deterioration and significant loss of weight. Nayar and Rajendran (1988) clarified that, if sweet potato is stored below 30°F, the tubers freeze and ruined by the chilling process. Ghosh et al. (1988) listed out its consequences including loss of Vitamin C, poor quality of tuber, increase in acidity and susceptibility to decay. Hence, the authors denied the technique of low temperature for prolonged storage of sweet potato.

2.4 Qualitative characteristics of fresh and stored tubers

Sweet potato is an energy rich crop as its tubers are mainly composed of starch. The starch granules of roots and tubers have been reported to have variety of shapes and sizes and amylose content depending on the crop. Rickard (1990) considered the functionally important properties of starch such as gelatinization, pasting and retrogradation which control the sensory attributes and stability of starch products. The author concluded that starch from various root and tuber crops differ in their intrinsic chemical properties.

2.4.1 Cooking and organoleptic qualities

Tsou and Hang (1988) pointed out that the starches from roots and tubers are generally more resistant to digestion. The authors suggested cooking of sweet potato as a solution to improve the protein digestability. Horward and Warren (1988) explained that heat treatment or cooking helps to degrade the cellulosic walls of the plant foods and the nutrients within are made more available to digest. Woolfe (1992 a) also highlighted the beneficial property of cooking sweet potato, as it increases the digestability of starch.

Brian and Allan (1982) observed that the potato starch grains were swelled and gelatinized; simultaneously the cellulose and pectin were found softened by prolonged cooking. The authors viewed that this makes the potatoes easier to eat. Horward and Warren (1988) classified the changes produced by cooking into those brought about by heat and those brought about by the effect of water or steam on the food. A report of Rickard (1990) proved that gelatinization takes place in sweet potato starch at a temperature range of 57 to 85°C. Woolfe (1992 a) and Madhu et al. (1993) evaluated that the amylase enzymes in sweet potato starch are becoming active during gelatinization. The authors believed this as the reason for increased sweetness of cooked tuber.

Kawabata et al. (1984) reported an increase in amount of total sugars and moisture due to boiling of tubers. The authors found that when stored cassava was boiled, the starch granules were ruptured within one hour. Lila (1988) assessed that the reducing sugars in sweet potatoes caused an increase from 1.62 to 25 per cent by boiling.

Commenting on the outcomes of different cooking methods, Bouwkamp (1985) reported that baking of sweet potatoes cause complete hydrolysis of starch, while in boiling only partial hydrolysis takes place, by decreasing the amount of insoluble pectin. Ghosh et al. (1988) explained that the high amount of amylase present in sweet potato is responsible for the breakdown of starch into dextrins and sugars while baking; which pronounces the sweetness of tuber. Cooking is often known to cause nutrient losses in tubers. Swaminathan (1977) reported small amounts of vitamin losses associated with cooking of tubers. Mishra (1987) judged that baking resulted in significant loss of vitamin C, when compared to boiling and pressure cooking. However, an encouraging fact has been reported by Woolfe (1988), that the retention of provitamin A, carotenoids is high both during storage and normal cooking of sweet potato.

Storage of sweet potato for a few days is said to improve the eating quality of the tuber (Kimber, 1972). Booth (1973) recorded longer cooking time for stored cassava, than is normally required for fresh tubers. The author pointed out the increased sugar content of stored tubers, that makes the tuber more palatable. Onwueme (1978) remembered that, besides, while cooking the starch convertion to maltose also makes the tuber much sugary to taste. Kays (1992) noticed that the pectins in sweet potato do not undergo substantial alterations during storage.

Balagopal and Padmaja (1985) found that the cooking quality of cassava stored in moist sand /soil was not affected up to one and a half months. Prema and Chellammal (1986) observed that the cooking time and rate of water uptake of cassava increased with the increased duration of storage. Sundaresan et al. (1990) noticed deterioration in cooking quality of yams, when the tuber turned to be hard after 4 months storage.

According to Hall (1968), the flavour of a substance denotes the sum of characteristics of the material which produces that sensation. John (1976) defined that flavour of a food material is a property of the material as well as of the receptor mechanism of the person eating or drinking the food. Padmaja (1985) reported significant flavour loss in sweet potato stored under less than 7 per cent oxygen. Horvat et al. (1991) studied a diversing range of flavours in different varieties of sweet potato. Laurin and Kays (1992) detected a tremendous genetic diversity in flavour and listed more than 20 flavours in 89 advanced clones of sweet potato.

Raja et al. (1978) obtained satisfactory results in the assessment of different organoleptic qualities such as appearance, colour, taste, texture and doneness of cassava tubers stored for 15 days. Raja et al. (1982) in an organoleptic trial of cassava found that there is no direct correlation between insoluble amylose content and stickiness of the starch. Padmaja and Rajamma (1982) noticed a bitter taste in weevil-fed tubers when stored in open conditions. Prema and Chellammal (1986) in a storage trial of cassava, observed that various attributes such as appearance, colour, taste, texture and doneness remained satisfactory upto the second week of storage in different depths of soil columns. Marcelo and Arsenio (1988) viewed that the flavour, texture and general acceptability of taro corms stored in rice hull ash was satisfactory upto 30 days. Nwufo (1988) revealed that the organoleptic qualities such as taste, colour, appearance, texture and odour of stored colocasia corms after fungicidal treatment were not impaired. Rai and Verma (1990) proved that the organoleptic qualities of chemically treated and stored potatoes were satisfactory. Best _et al_. (1990) reported that although microbial spray on tubers packed in polyethylene bags showed difference in external appearance after storage, the eating quality was maintained upto two weeks.

2.4.2 Changes in nutritional composition by storage

According to Padmaja (1990), storage of sweet potatoes beyond one month will adversely affect its nutritional qualities. While storage of fruits, there was a gradual rise of sugar content due to the starch hydrolysis by ripening (Rangavalli _et al_.1993). The same trend have been reported in tubers also.

Balagopal and Moorthy (1984) and Uritani and

Reyes (1984) noticed an essential increase of sugars and a decline in total starch within two weeks storage of tubers. This was considered to be the reflection of metabolic changes. According to Coffin _et al_.(1987), the amount of sugars varies depending on the variety of tuber. Madhu _et al_.(1993) indicated that the post harvest method of storage is one of the factors which influence the extent of starch convertion to malto oligo saccharides and dextrines. But, Joseph and Cecilia (1994) reported contradictory to this, stating that the rate of starch degradation was similar in all tubers, irrespective of the storage methods used.

Maini (1976) reported that a part of starch is converted to reducing sugars and subsequently into sucrose, during storage. The author recorded a starch reduction from 19.1 to 14.1 per cent and the increased range of reducing sugar (as dextrose) and sucrose from 0.9 to 1.7 and 1.9 to 6.1 percentages respectively by 5 months storage of sweet potato. Maini and Balagopal (1978) observed 15 to 20 per cent reduction of starch in cassava, by 2 months storage under moist sand/soil; while the same reduction was occured by one week storage at ambient conditions. Sowokinos et al. (1987) found that sucrose is the principal sugar showing most notable increase with storage. The authors marked more than 65 per cent of maximal sugar accumulation within 5 days of handling of potatoes. Ghosh et al.(1988) noticed 10 per cent increase in reducing sugars by 2 months and 150 per cent increase on seven months storage. Padmaja (1990) indicated 50 per cent loss in starch after 6 months storage, and reported a concomitant increase in glucose, fructose and sucrose contents. Sundaresan et al. (1990) recorded a starch reduction from 59.4 to 49 per cent and 10 per cent moisture loss by 120 day's storage of yams. Horvat et al. (1991) opined that the difference in concentration of total sugars were only quantitative while storage of sweet potato. Lila and Nambisan (1991) detected that the starch and reducing sugars caused a decreasing trend by sprouting, while total sugars remained more or less unchanged in sweet potatoes.

Misra and Chand (1989) found a negative relationship between the tuber size and amount of reducing sugars. The same relation was reported with total phenols also. Padmaja (1990) noticed a decreased trend of ascorbic acid content by storage of sweet potato. Rai and Verma (1990) assessed that only 15 to 16 per cent of the initial ascorbic acid was left after seven months storage of potatoes. Padmaja (1990) reported an increase in the carotenoid content during storage of sweet potato. Bhushan and Thomas (1990) found no interrelationship between the lipoxygenase activity and destruction of carotenoids in irradiated potatoes.

Hameed et al. (1980) observed that low temperature storage also brings about decrease in starch and increase in sugars of cassava. Coffin et al. (1987) noticed a greater increase in sugars at a storage temperature of 5°c. But, Mehta and Kaul (1988) reported a lesser increase in reducing sugar of potatoes stored in evaporatively cooled structures, compared to refrigerated storage for 14 weeks.

Mishra (1985) revealed that the rate of decrease in ascorbic acid content of tubers was more in low temperature (2 to 4°c), than in high temperature (24 to 36°c) storage. However, Mondy and Gosselin (1987) mentioned that temperature of storage does not affect the ascorbic acid, but greatest accumulatuion of phenols occured at 5°c, and the highest total glyco alkaloid at 20°c storage. Wu et al. (1991) recorded 50 per cent decrease of vitamin C content in frozen pre-baked sweet potato by one month storage. Bhushan and Thomas (1990) found that the carotenoid content of potatoes tend to decrease at 5°c and 20°c storage.

From the review, it is evident that no single storage method could fully satisfy all the factors essential for an ideal storage technique. However, it was found that storage of tubers in certain methods gave comparatively better results, under ordinary conditions. It would be an important advance to devise suitable methods of post harvest storage, which avoid deterioration of the tubers.

MATERIALS AND METHODS

MATERIALS AND METHODS

Outline of the investigation carried out under the present study on "Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods" can be listed as:

3.1 Collection of most commonly cultivated local variety of sweet potato tuber.

3.2 Selection of storage media.

3.3 Storage of the tuber using different media selected.

3.4 Assessing the shelf life of the stored tuber at different durations with reference to:

3.4.1 Nature and extent of post harvest damage.

3.4.2 Changes in cooking characteristics of undamaged tubers.

3.4.3 Changes in organoleptic qualities and acceptability of the cooked tubers.

3.4.4 Changes in nutritional composition of undamaged tubers.

3.5 Statistical analysis of the results.

3.1 Collection of most commonly cultivated local variety of sweet potato tuber

From enquiries made at the nearest Krishi bhavan located at Venganoor panchayat, in Thiruvananthapuram district, it was found that the accession "vavvathoki" is one of the most commonly and widely cultivated types of sweet potato by the local farmers in Thiruvananthapuram. About 65 kilograms of the tuber of approximately uniform size and free from pests and diseases were collected immediately after harvest. Damaged and bruised tubers while harvesting were discarded, since bruises and injuries in the tuber may limit the storage life, as reported by Bouwkamp (1985) and Mondy et al. (1987).

3.2 Selection of storage media

Local availability of the storage materials to the farmers is of utmost importance, inorder to make use of the successful results. In the study, indigenous, lowcost media with waste or unused materials as detailed below were used for fabricating storage system.

3.2.1 Ordinary basket

3.2.2 Saw dust

3.2.3 Mud coating

3.2.4 Paddy husk

3.2.5 Coir pith

3.2.6 Polythene cover

3.2.7 Waste carbon paper and

3.2.8 kept open as control.

3.2.1 Ordinary basket

The practice of storing fresh vegetables, fruits, roots and tubers in baskets has been found very common among the Keralites. Onwueme (1978) has reported the utilisation of ordinary baskets by the people in the ancient tropics for storage of sweet potato tuber.

Therefore, its effectiveness in the storage of sweet potato tuber was tried in this study.

3.2.2 Saw dust

In an earlier study, saw dust was found to be superior for long term storage of tubers (Pillai _et_ _al_. 1969). Later in 1985, James also reported the effectiveness of saw dust in improving the shelf life of cassava roots. Hence, studying the storage capability of sweet potato in this medium was considered.

3.2.3 Mud coating

Storing cassava tuber in soil column was found to be a suitable method for popularising among rural families (Prema and Chellamal, 1986). In an earlier study, improvement of shelf life of tubers by mudcoating was reported (Anon., 1983). Hence, storage trials by coating sweet potato tuber with mud was attempted in this study.

3.2.4 Paddy husk

Being a readily available material in the farm, paddy husk was tried as a storage medium in the present investigation. Marcelo and Arsenio (1988) has also reported the effectiveness of ricehull ash to store taro corms, beyond 14 days.

3.2.5 Coir pith

Coir pith is a waste and unused material available in the villages in Kerala. Effectiveness of moist coir dust for storing cassava tuber have been tried in Jamaica (Marriot et al., 1974). Hence, its feasibility as a cheap storage medium was attempted.

3.2.6 Polythene cover

Use of polythene bags without perforations was reported to store tubers immediately after harvest, in the earlier days. Best et al. (1990) observed that cassava roots packed in polythene covers were of higher quality.

Used polythene covers were selected as a medium for storage of sweet potato, after giving perforations to lessen humidity inside the covers.

3.2.7 Waste carbon paper

Used carbon paper which is a total waste and available free of cost, could be tried for the purpose of storage of tubers. According to Mukhopadhya et al.(1991), waste carbon paper is an effective material to improve shelf life of sweet potato tuber.

3.2.8 Kept open as control

Tubers kept openly on the floor functioned as the control for comparative study with the various experimental methods selected for storage.

Since most of the storage materials being waste items, storage cost can be minimised to a very great extent. Moreover, these materials are available at any time, compared to the expensive methods like use of chemical preservatives, wax as well as cold storage, these are more practicable and adaptable in fields. Besides, these methods may not involve any risk or health hazards.

3.3 Storage of the tuber using different media selected

The experiment was carried out in a room with ambient condition and was setup on the same day on which the tuber was harvested. The relative humidity and temperature of the storage room were recorded daily. Figure 1 illustrates the weather data of the storage room. Details of the procedures on storage of sweet potato tuber using different media are furnished below:

Four sets (in duplicate) were setup in each medium. Two kilograms of freshly harvested tubers were placed in each set. This was followed uniformly for all the seven treatments and control. Treatments given were as follows:

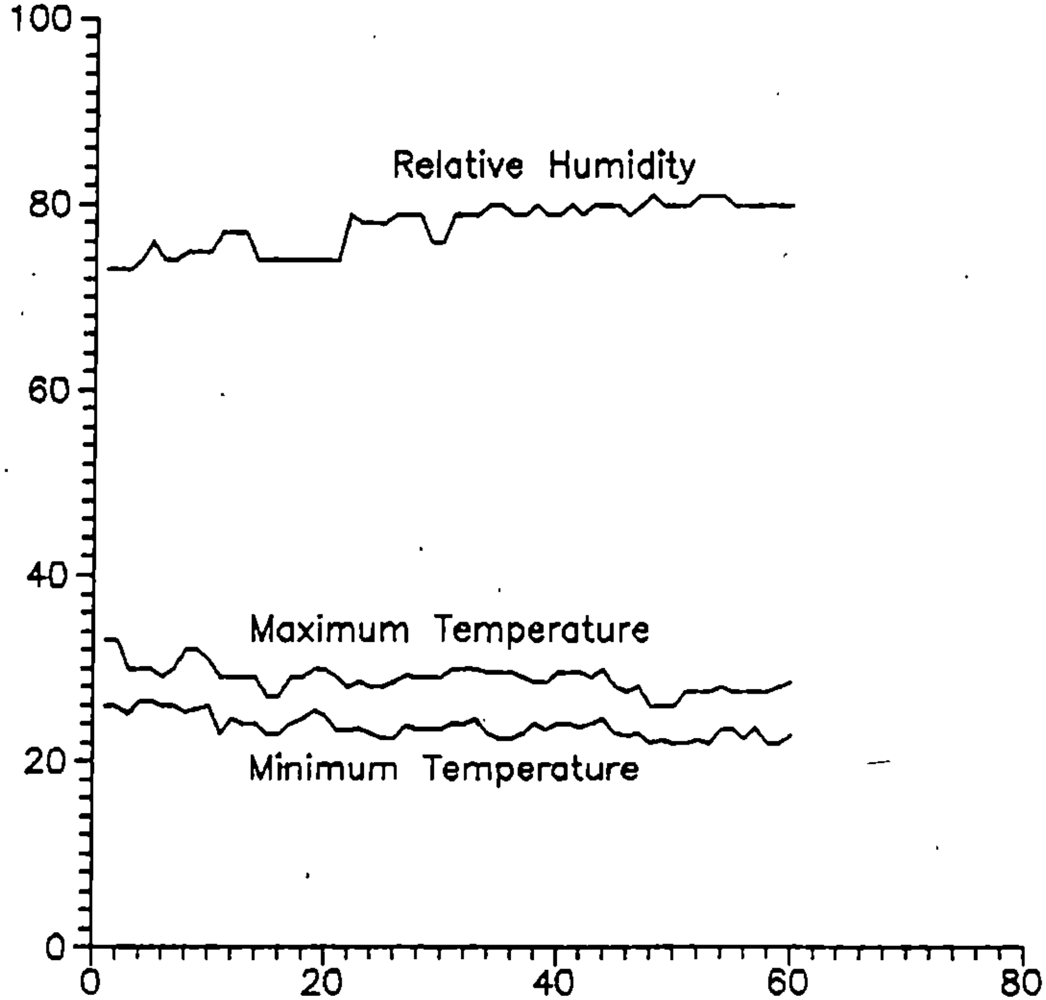


Figure 1. Temperature(°C) and Relative humidity (%) of the storage room during storage study.

i. Tubers were weighed and placed in ordinary baskets (T_1) (Plate 1).

ii. Weighed quantity of tubers were placed above a bed of saw dust (T_2) in 5 centimetres thickness. While arranging each row, the tubers are separated by a saw dust bed of 2 centimetres thickness. Each set was covered again with 5 centimetres thickness saw dust bed (Plate 2). Saw dust used was freshly collected from the nearby saw mills, one month before the experiment. Saw dust was sun dried before storage and the moisture level was recorded as 11 per cent.

iii. Required quantity of the tuber was coated with mud paste (T_3) and placed in the experiment room (Plate 3). The red sticky surface soil available in the locality was used for making mud paste. Tubers were adequately coated with mud so that the entire portion of each tuber could be covered fully.

Plate 1. Storage of sweet potato in ordinary basket.

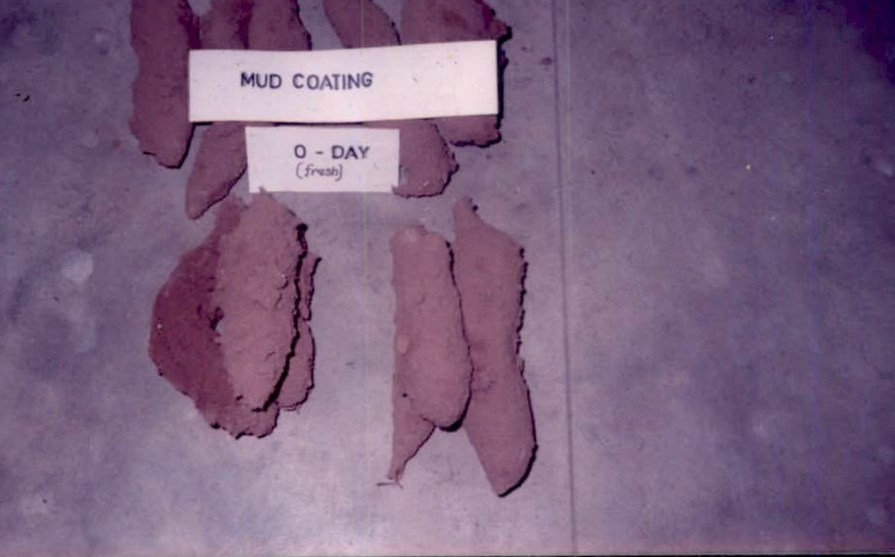
Plate 2. Storage of sweet potato in saw dust.


0 - DAY
(fresh)


0 - DAY
SAW DUST

Plate 3. Mud coated storage of sweet potato.

Plate 4. Storage of sweet potato in paddy husk.


MUD COATING
0 - DAY
(fresh)


0 - DAY
(fresh)
PADDY HUSK

iv. Paddy husk was collected from the farm families and weighed quantity of sweet potato tubers were placed above a bed of paddy husk (T_4) (Plate 4), following the same procedure as in the case of saw dust. The moisture content of the paddy husk used was detected as 10 per cent.

v. Coir pith collected from coir makers was sun dried before setting the experiment. The moisture content of coir pith after drying was found as 9 per cent. Weighed quantity of sweet potato tuber was also placed in coir pith (T_5) (Plate 5) as detailed in the case of saw dust and paddy husk.

vi. Ordinary polythene covers of size 30 x 35 centimetres were chosen for the study. Pinhole size perforations within two centimetres were made and the covers were sterilized by dipping in hot water and sun dried. The tuber was weighed, packed inside these covers and heat sealed properly and kept for storage (T_6)

Plate 5. Storage of sweet potato in coir pith.

Plate 6. Storage of sweet potato in polythene covers.


O - DAY
COIR PITH.


POLYTHENE COVERED
O - DAY
(fresh)

(Plate 6).

vii. The weighed quantity of sweet potato tuber was covered separately with three layers of waste carbon paper (T_7). These were then placed above a layer of carbon paper spread on the floor (Plate 7).

viii. The tubers after weighing left openly on the floor without using any storage media. This functioned as the control (T_0) in the storage study (Plate 8).

Observations were recorded at varying intervals of:

a. 15 days after storage.

b. 30 days after storage.

c. 45 days after storage.

d. 60 days after storage.

One set of tubers from each treatment in replicate was disturbed at a time for the periodical observations recorded once in 15 days over a period of 60 days. This enabled the sound storage of remaining sets

Plate 7. Storage of sweet potato in waste carbon paper.

Plate 8. Openly stored sweet potato to serve as control.


CARBON PAPER
0 - DAY
(fresh)


CONTROL
0 - DAY
(fresh)

which were withdrawn at the next stage. Samples were analysed for assessing shelf life qualities using different parameters.

3.4 Assessing the shelf life of the stored tuber at different durations

The shelf life of the stored tubers under different treatments upto 60 days was assessed by studying the following parameters:

3.4.1 Nature and extent of post harvest damage

The nature and extent of damage and deterioration on different durations of storage was studied by testing the tubers for weevil infestation, weight loss, symptoms of rotting, incidence of sprouting and other physical changes associated with storage.

The extent of damage caused by weevil attack in sweet potato tubers stored under different treatments for the progressive periods was worked out in terms of

Damage Grade Index (DGI) using a six point scale as per the method reported by Palaniswami (1987).

Grading based on the DGI was done through a close examination of the tuber surface and examining the internal portion by sectioning the tuber. Ratings alloted for the two replications were considered for calculating the Grade Point Average (GPA). Mean value was taken as DGI of the sample.

The loss of weight of stored samples were determined by measuring the changes in weight of each sample at regular intervals of storage from that of in the sample before storage.

Symptoms of rotting, sprouting and other physical changes such as shrivelling, softening and drying occured in stored samples were assessed by visual observation of each tuber at different durations of the study.

3.4.2 Changes in cooking characteristics of undamaged tubers

Sweet potato tuber stored under different storage media and undamaged during observation was assessed for their cooking characteristics.

The cooking characteristics studied were:

1. Optimum cooking time
2. Apparent water absorption

1. Optimum cooking time was determined by the method suggested by Bhattacharya and Souwbhagya (1971).
2. Apparent water absorption was estimated by the method of Bhattacharya and Souwbhagya(1971)

3.4.3 Changes in organoleptic qualities and acceptability of the cooked tuber

Organoleptic qualities of the stored tuber under different storage media were assessed using the optimum cooked samples. Simple boiling method was followed for cooking the tubers.

Panel members for the sensory evaluation were selected after initial screening through a simple triangle test as suggested by Jellinek (1985). The evaluation card used for triangle test is presented in Appendix 1. From the twenty women who participated in the triangle test, ten women were selected as judges for the present study. Small, highly sensitive panels would give more reliable results than large less sensitive groups (Amerine et al. 1965). The selected panel members were between the age group of 20 to 40 years.

Sensory analysis of the cooked samples of stored tubers were carried out at the laboratary with the selected panel of judges. Scoring test was used for quality evaluation as suggested by Swaminathan (1974). A five point rating scale was applied for each qualities. The major quality attributes included for scoring were appearance, colour, taste, flavour, texture and doneness. A score card on these lines were prepared and distributed among the panel members to express their scores for organoleptic quality of the samples. Details of the score card is presented in Appendix 2.

The panel of judges were served with the cooked samples of tuber. Water was given in between tasting each samples for the removal of any after taste carried over from one sample to the other. Judges were also permitted to take enough time to score the samples leisurely. The testing was conducted in the mid morning between 10 A.M and 11 A.M. Since this time is considered as the ideal time for conducting the quality evaluation studies (Swaminathan, 1974).

3.4.4 Changes in nutritional composition of undamaged tubers

Fresh sweet potato tubers and stored samples at four different storage durations were analysed for changes in nutritional composition. Major nutritional qualities analysed were moisture, starch and reducing sugar.

The details of the analysis of nutritional composition of stored sweet potato tuber under different methods and at different durations were as follows:

i. Fresh sweet potato tuber and stored samples were analysed for its progressive changes in moisture content following the method reported by Ramulu _et al_. (1983).

ii. Starch content of the samples of fresh and stored sweet potato tuber under different treatments were analysed at regular intervals of 15 days following the copper reduction method as reported by the A.O.A.C. (1960).

iii. Reducing sugar of the fresh sweet potato tuber and stored samples were analysed at different durations as per the procedure suggested by the A.O.A.C (1960).

3.5 Statistical Analysis of the results

Analysis of variance was applied to the experimental data for the interpretation of results.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The study entitled "Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods" was conducted to detect and develop satisfactory techniques for prolonged storage of sweet potato tuber. The results of the investigation are presented and discussed, with reference to:

4.1 Nature and extent of damage in stored sweet potato tubers.

4.2 Changes in cooking characteristics of undamaged tubers, due to storage.

4.3 Changes in organoleptic qualities and overall acceptability of cooked tubers, due to storage.

4.4 Changes in nutritional composition of undamaged tubers, due to storage.

4.1 Nature and extent of damage in stored sweet potato tubers.

Shelf life qualities were ascertained by studying the nature and extent of damage caused during storage of sweet potato. The different parameters comprised weevil infestation, weight loss, symptoms of rotting, sprouting and other physical changes during storage. Data were collected from sweet potato tubers stored under different treatments on 15th, 30th, 45th and 60th days.

4.1.1 Effect of storage treatments on weevil infestation of sweet potato tuber

Among the borer pests, the sweet potato weevil (Cylas formicarius Fab.) was reported to be the most distinctive and predominant one which caused heavy damage in storage (Ghosh et al. 1988). The effect of storage treatments on the incidence of sweet potato weevil, depicted as damage grade index, is given in Table 1. The data on damage grade index of sweet potato stored under different methods was statistically analysed and the abstract of Anova is presented in Appendix 4.

Data presented in Table 1 revealed that different storage treatments had significant effect on the incidence of sweet potato weevil. T_0 had the highest damage index of 3.25 which was on par with T_3 and significantly superior to other treatments. T_7 had no weevil damage and the damage grade index was 0.

The results indicated that the tubers of all storage treatments under study were free of weevil damage when inspected on the 15th day of storage (Plates 9 and 10). Weevil infestation was noticed on the 30th day of storage in three treatments namely T_0 (control), T_3 (mud coated) and T_6 (polythene covered). In T_6, external feeding damage and oviposition marks were noticed only on less than 25 per cent of tuber surface, without any internal damage; while T_0 and T_3 recorded internal damage also extending over less than 25 per cent of the tuber.

Table 1. Damage grade index of stored sweet potato tubers

Storage treatments	STORAGE DAYS 15	30	45	60	Treatment mean
T_1	0(1)	0(1)	1(1.37)	5(2.45)	1.5(1.45)
T_2	0(1)	0(1)	0(1)	1(1.37)	0.25(1.09)
T_3	0(1)	3(1.98)	4(2.22)	5(2.45)	3(1.91)
T_4	0(1)	0(1)	1(1.37)	3(2)	1(1.34)
T_5	0(1)	0(1)	1(1.41)	3(1.98)	1(1.35)
T_6	0(1)	1(1.37)	3(1.98)	4(2.22)	2(1.64)
T_7	0(1)	0(1)	0(1)	0(1)	0(1)
T_0	0(1)	3(1.98)	5(2.45)	5(2.45)	3.25(1.97)
Duration mean	0(1)	0.875 (1.292)	1.875 (1.810)	3.250 (1.990)	

F test: Me.=16.778.** Pe.=50.239.** Me.x Pe.=3.408.**
CD: Me.=0.273. Pe.=0.174. Me.x Pe.=0.491.

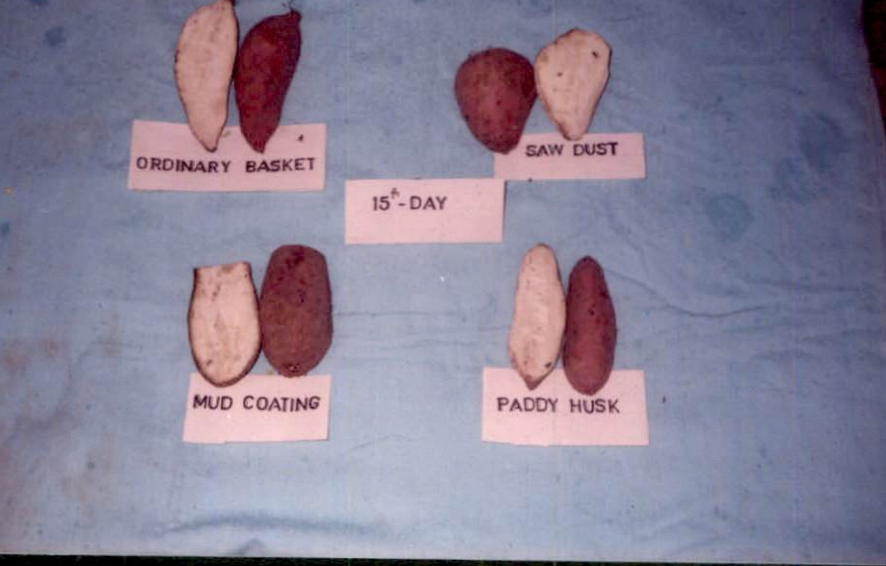
T_1 = Ordinary basket. T_2 = Saw dust. T_3 = Mud coating.

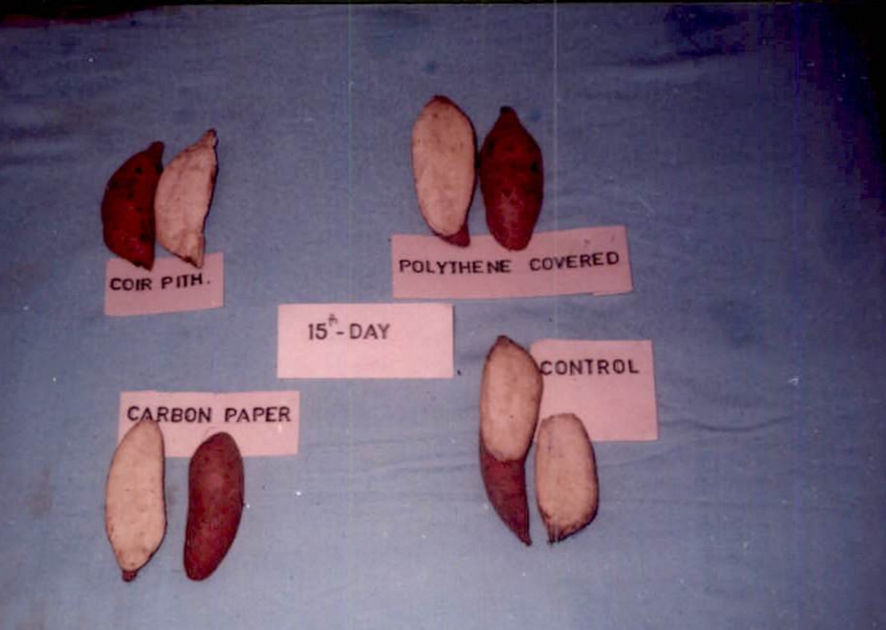
T_4 = Paddy husk. T_5 = Coir pith. T_6 = Polythene covered.

T_7 = Waste carbon paper. T_0 = Control.

Note: ** = Significant at 1 % level. Figures in paranthesis are transformed values in square root x+1. F test and CD of transformed values are given.

Plates 9 & 10. Sweet potato tubers on 15th day of storage.


ORDINARY BASKET
SAW DUST
15th-DAY
MUD COATING
PADDY HUSK


COIR PITH.
POLYTHENE COVERED
15th-DAY
CONTROL
CARBON PAPER

On the 45^{th} day of storage, weevil infestation was observed in all other treatments except in T_2 (saw dust) and T_7 (waste carbon paper). As agreeable with the trend showed on the 30^{th} day of storage, maximum infestation was noticed in T_0, followed by T_3 and T_6 on the 45^{th} day of storage also. The T_0 recorded more than 50 percent internal damage during the period. T_6 recorded only less than 25 percent internal damage, while it was about 25 to 50 percent in T_3. The external feeding damage and oviposition marks in T_1 (ordinary basket), T_4 (paddy husk) and T_5 (coir pith) accounted for only less than

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Foot note: Assessment of damage grade index on tuber:

0 = Free from weevil damage.

1 = External feeding damage and oviposition marks on less than 25 per cent of tuber surface, but without internal damage.

2 = External feeding damage on more than 25 per cent tuber surface, but without internal damage.

3 = Internal damage extending over less than 25 per cent portion of tuber.

4 = Internal damage 25 to 50 per cent.

5 = Internal damage above 50 per cent.

Source: Palaniswami (1987).

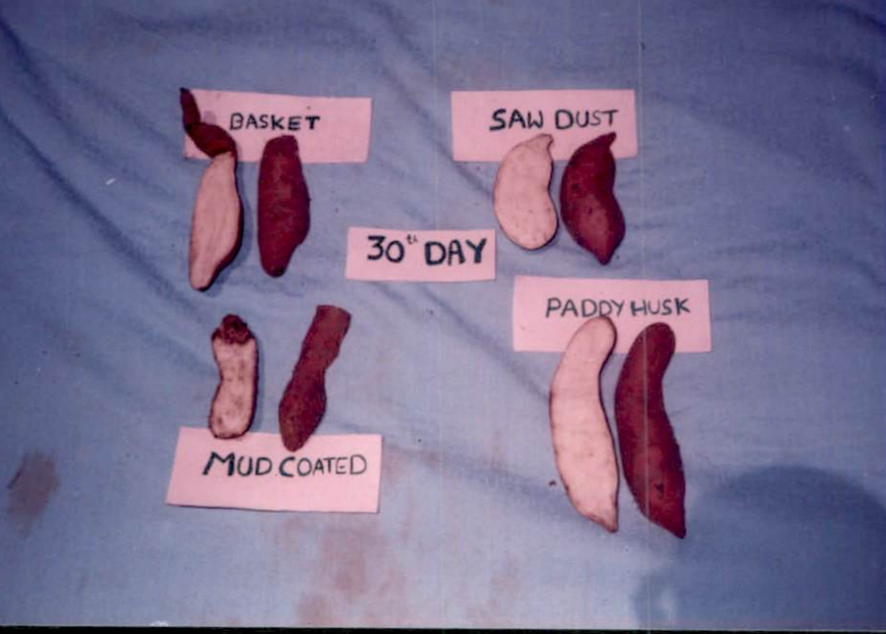
25 per cent portion of tuber surface, but without any internal damage.

During the 60th day of storage, it was found that T_1, T_3 and T_0 recorded 100 per cent spoilage, while T_7 was found completely free from weevil damage. Now, T_2 recorded an external feeding damage and oviposition mark on less than 25 per cent of the tuber surface, but without internal damage. T_4 and T_5 recorded less than 25 per cent internal damage, while it was about 25 to 50 per cent in T_6. The treatments 4, 5 and 6 were at par while T_6 was at par with T_0, T_1 and T_3.

As presented above, the sweet potato stored by various methods in the present study were free from weevil damage when observed on 15th day. Similar results were observed by Prasad et al.(1981), as the authors reported the absence of weevil damage in sweet potato tuber during the first 15 days of storage.

But, in the present study, weevil infestation was observed in T_0, T_3 and T_6 on the 30th day, while all other treatments were free of weevil damage (Plates 11 and

Plates 11 & 12. Sweet potato tubers on 30^{th} day of storage.


BASKET
SAW DUST
30th DAY
PADDY HUSK
MUD COATED


POLYTHENE COVERED
STORED IN COIR PITH
30th DAY
WASTE CARBON PAPER
CONTROL

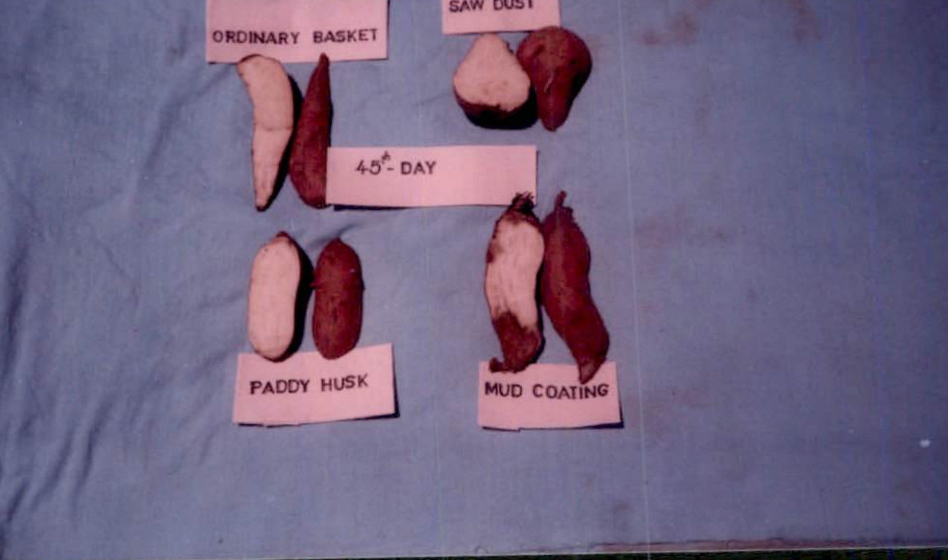
12). According to Rajamma (1984), sweet potato tubers kept in open conditions recorded 100 per cent damage due to weevil infestation after one month of storage. In the present study, the sweet potato kept at open conditions (T_0) recorded only less than 25 per cent of internal damage on the first month of storage and then on the 45^{th} day, the same increased to above 50 per cent. Studies conducted by Prasad et al. (1981) had revealed that the loss due to weevil infestation increased with the period of storage.

Even though mudcoating has been reported to be helpful in improving shelf life of tubers (Anon., 1983); this treatment was not found to be very effective for storage of sweet potato tuber beyond the duration of 15 days in the present study. Mud coated tubers (T_3) were also found to be less resistant to weevil attack. As the mud paste above the tuber gets dried up, the weevil started boring into the tuber. The polythene covered tubers (T_6) were also easily attracted by weevil within one month of storage. The weevil made its way through the perforations on the cover. Hence, this treatment can be considered as a satisfactory one for 30 days of storage of sweet potato.

Even though the tubers kept in ordinary baskets (T_1) were having enough chances of weevil attack as it was placed uncovered in the baskets, the tubers were free from weevil damage upto the 30th day of storage. The tubers kept in paddy husk (T_4), in coir pith (T_5) and in ordinary baskets (T_1); which were free from weevil incidence upto 30 days, were found attacked by weevil on the 45th day of storage (Plates 13 and 14). Since there was only external damage below 25 per cent, these three treatments can be considered feasible upto 45 days of storage of sweet potato.

According to Marriot <u>et</u> <u>al</u>.(1974) and Thampan (1979), the cassava tubers kept inside moist coir dust prolonged the storage life to 28 days. Much encouraging results were obtained in the present investigation, as the coir pith medium having a moisture content of 9 per cent could improve the shelf life of sweet potato to 45 days. The effect of paddy husk was observed to be similar to

Plates 13 & 14. Sweet potato tubers on 45th day of storage.


ORDINARY BASKET
SAW DUST
45th - DAY
PADDY HUSK
MUD COATING


COIR PITH.
POLYTHENE COVERED
45th - DAY
CONTROL
CARBON PAPER

that of coir pith in protecting sweet potato from weevil damage in this study.

Saw dust was suggested by many workers for storing tubers. Ghosh et al. (1988) found that moist saw dust is an effective medium for storage of tubers upto 56 days, the provided medium should not be wet, as it leads to spoilage. Mukhopadhya et al.(1991) also reported that saw dust could protect 20 to 30 per cent of sweet potato tuber from spoilage, when stored upto 90 days. In the present study, saw dust having a moisture content of 11 percent was observed as an effective medium for successful storage of 75 per cent of sweet potato tuber, upto 60 days. Spoilage was very limited in this medium, compared to paddy husk and coir pith.

From this study, it was evident that waste carbon paper covering can keep sweet potato tuber completely free from weevil incidence for the entire period of study (60 days). Mukhopadhya et al. (1991)) also proved waste carbon paper as the best medium for storage of sweet potato tuber, probably because of the repellent action of the carbon paper against weevil.

The present storage trial proved saw dust as a successful medium for storage in the aspect of weevil attack, as it could safe guard 75 per cent of tubers upto 60 days. Coir pith and paddy husk were also studied to be moderately successful that could extend shelf life upto 45 days. However, carbon paper covering can be considered as a superior method for checking weevil attack for prolonging shelf life of sweet potato tuber considerably.

4.1.2 Influence of storage treatments on weight loss of sweet potato

Loss of weight is an important factor which determines the shelf life quality of tuber. Table 2 depicts the percentage decrease in weight of the stored sweet potato tubers recorded at four intervals of the present study.

The data presented in Table 2 revealed that the percentage weight loss due to storage was significantly varying in different treatments.

Table 2. Effect of storage treatments on weight loss of sweet potato at different durations (per cent)

Storage treatments	STORAGE DAYS			
	15	30	45	60
T_1	19.20	27.50	36.00	—
T_2	12.00	15.00	22.00	31.00
T_3	22.05	30.00	40.10	—
T_4	17.00	19.00	24.00	32.00
T_5	10.00	15.00	21.00	28.00
T_6	8.00	12.00	17.00	24.00
T_7	11.00	14.00	18.00	26.00
T_0	23.00	36.00	—	—

T_1 = ordinary basket. T_2 = saw dust. T_3 = mud coated.

T_4 = paddy husk. T_5 = coir pith. T_6 = polythene covered.

T_7 = waste carbon paper. T_0 = control.

When the stored samples were observed on the 15^{th} day, significant loss of weight was found in treatments T_0 (control), T_3 (mud coated) and T_1 (ordinary basket). However, these three treatments maintained 77 to 81 per cent of tuber weight, while T_4 (paddy husk), T_2 (saw dust), T_7 (waste carbon paper), T_5 (coir pith) and T_6 (polythene covered) could maintain 83 to 92 per cent of fresh weight. Weight loss was lowest in T_6 (8 per cent), followed by T_5 (10 per cent), T_7 (11 per cent), T_2 (12 per cent) and T_4 (17 per cent). Maximum weight loss was recorded in control (23 per cent), followed by tubers; mud coated and stored in baskets (22 and 19 per cent respectively).

Observation on the 30^{th} day of storage indicated that loss of weight was significantly higher in T_0 (control), followed by T_3 (mud coated) and T_1 ordinary basket). These three treatments could maintain only 64 to

73 per cent of initial tuber weight where as T_4, T_2, T_5, T_7 and T_6 maintained 81 to 88 per cent of fresh weight of tubers. Minimum weight loss was observed in treatment 6, followed by 7, 2, 5 and 4. Among these five samples that performed, T_4 (paddy husk) was more prone to weight reduction. Treatments 2 and 5 showed similarity in weight loss, which maintained 85 per cent of fresh weight.

When samples were stored upto 45 days, the control (T_0) was completely dried up and was fully infested indicating the futility of the method. The weight of mud coated tuber (T_3) was found decreased to 59 per cent which recorded the maximum weight loss, and tubers stored in ordinary basket (T_1) had 64 per cent of fresh weight. Treatments 4, 2, 5, 7 and 6 could maintain 76 to 83 per cent of initial tuber weight. Tubers kept in polythene covers (T_6) recorded the lowest weight loss, followed by T_7 (waste carbon paper), T_5 (coir pith), T_2 (saw dust) and T_4 (paddy husk).

Tubers stored in ordinary basket (T_1) and mud coated (T_3) were also found not worthy enough to record weight due to damage on 60th day of storage. Among rest of the five treatments, T_4 suffered the greater weight loss which maintained 68 per cent of fresh weight. Maximum weight was retained in T_6 which could keep up 76 per cent of fresh weight, followed by T_7 (74 per cent), T_5 (72 per cent) and T_2 (69 per cent) over 60 days.

According to Data and Eronico (1987), loss of fresh weight is a common observation during storage, whatever be the treatment applied for storage. In the present study, a comparison of fresh tuber weight with that of the tubers stored in different media indicated that initially there was only a limited loss of weight, but as the duration of storage increased, a steady decrease in weight was observed in all the treatments. A similar decrease in weight due to dehydration, which increased with storage period has been reported by Balagopal and Padmaja (1985).

It was found that the tuber kept exposed as control showed the maximum loss of weight. Mehta and Kaul (1987) and Bhandal and Naik (1991) also observed higher weight loss in exposed potato sample in a storage trial. Increased rate of dehydration was the cause for this greater weight loss. Due to the same reason, samples kept in ordinary basket (T_1) also were observed to have significant loss of weight. In this study, the mud coated tubers (T_3) were also highly susceptible to loss of weight on storage. Significant dehydration and higher incidences of weevil and microbial attack of the tuber could be the cause for such a higher loss of weight. As reported by Adesuyi (1973) and Bhatia et al.(1991); microbial attack, weevil infestation and sprouting pronounces the weight loss.

The fall in weight of T_4 (paddy husk) was higher when compared to similar media tried, such as coir pith and saw dust. This indicated that respiration rate of tubers was greater when kept in paddy husk. Kushman and Wright (1969) reported that respiration causes considerable weight loss of stored tubers. Besides, these tubers were more prone to sprouting. According to Adesuyi (1973), sprouting enhances the weight loss.

Even though the tubers were kept in polythene covers (T_6), it suffered from both weevil attack and sprouting, the fall in weight was least compared to all other storage treatments studied. Thompson et al. (1973) in their investigations found that yam tubers stored in polyethylene bags lost only little weight during storage, even though sprouting and microbial incidences were higher. This may probably be because of reduced air movement within the polythene covers. According to Ajayi and Madueke (1990), weight loss was greater at higher ventilation levels. Even though 76 per cent of weight was restored in polythene covered treatment, the tubers exhibited spoilage symptoms faster. This limited its feasibility for prolonged storage. Since spoilage was developed beyond the storage period of 30 days, this method could be considered highly advantageous for storage upto 30 days when weight loss is considered.

Coir pith also was detected as a successful medium to limit the weight loss of stored sweet potato in the present study. Coir pith was found to maintain 72 per cent of initial weight of tubers on 60^{th} day of storage.

A special quality of moist coir pith have been reported by Roshni (1993). The author states that the evaporation activity of this substance is very low due to the higher moisture holding capacity of the coir pith. This property of moist coir pith may not allow the tubers stored inside it to loose water by evaporation, there by limiting weight loss.

In an earlier study conducted by Mukhopadhya et al.(1991), saw dust was observed to maintain 31 per cent of fresh weight of sweet potato on 60^{th} day of storage. Much promising and superior results were obtained in the present study, since saw dust having 11 per cent moisture content was found effective to maintain 69 per cent of fresh weight on 60^{th} day of storage.

Waste carbon paper proved as a superior storage medium to resist weight loss of sweet potato, when results were correlated with the extent of damage occured in the study. Mukhopadhya et al.(1991) reported that waste carbon paper could maintain 60 per cent of fresh weight of sweet potato on the 60^{th} day of storage.

Present study further strengthened this finding, as 74 per cent of fresh weight was maintained in sweet potato upto 60 days, covered in waste carbon paper. Besides carbon paper, coir pith and saw dust (T_5 and T_2) were also viewed appropriate to check weight loss during the storage.

4.1.3 Symptoms of rotting observed with storage of sweet potato under different methods

Spoilage of tubers caused by microbial rotting is a common storage problem. The symptoms of rotting recorded in sweet potato tubers stored under different methods for different durations in the present study revealed interesting findings.

No symptoms of storage rot in the tubers were recorded till the 15th day of storage. The same trend was continued till 60th day of storage in all the treatments except in tubers stored in T_0 (control), T_1 (ordinary basket) and T_3 (mud coated).

At 30th day of storage, T_0 (control) and T_3

(mud coated) where observed with signs of rots on the tuber; while all the other treatments benefited the tubers to keep free of rots. The nature of rot in T_3 was viewed to be black coloured and decay starting from one end of the tuber. Along with that, the tuber was seen wrinkled, shrunken and mummified. In T_0, there formed a hard texture and when cut opened, the internal flesh was seen brownish in colour, along with round, brownish-black spots on the tuber. The proportion of rot infection increased significantly in T_3 and T_0, on the 45th day of storage; whereas the remaining six treatments were still free of rotting symptoms. Samples kept as control (T_0) became very much hard, brittle and difficult to break, while T_3 (mud coated) was observed with pronounced symptom of brown coloured rot which spread towards the middle of the tuber, along with increased mummification and decay. The six treatments such as T_7 (waste carbon paper), T_6 (polythene covered), T_5 (coir pith), T_4 (paddy husk), T_2 (saw dust) and T_1 (ordinary basket) were found to be free from symptoms of storage rots upto 45th day.

However, signs of rotting appeared in T_1 on the 60^{th} day, while the other five treatments were found free from signs of rots even on the 60^{th} day of storage. A corresponding increase in rotting was marked in T_0 (control) and T_3 (mud coated). Black coloured fungal spores were seen attached to the surface of tubers in T_0. The outer skin of tubers in T_3 was wrinkled, brittle and was too hard to cut with a knife, exhibiting a dark brownish-black powdery texture by the internal surface of the tuber. T_1 (ordinary basket) also carried black coloured fungal spores above the tuber surface, though it was devoid of symptoms of rots upto 45 days. Thus, three treatments including T_0, T_1 and T_3 were completely spoiled much before the expiry of the experiment, where tubers became unfit for consumption.

According to Prasad et al.(1981), the signs of rots in undamaged tubers were observed after the second week of storage. Highly encouraging results were noted in the present study that all the treatments except T_1, T_3 and T_0 were distinguished and survived free from this usual damage on storage over a period of 60 days. Even the samples such as T_0 and T_3 were having higher susceptibility to spoilage, rotting symptoms was noticed only on the 30th day of storage.

Sweet potato tuber cannot be kept satisfactorily in ordinary baskets for more than one month, as spoilage is a common problem (Onwueme, 1978). However, as observed in the present study, the tubers kept in ordinary baskets (T_1) were free of microbial spoilage upto 45 days.

Since T_3 (mud coated) and T_0 (control) showed signs of rots on the 30th day, these tubers were unfit for consumption beyond the first month of storage. The symptoms of decay seen on T_3 (mud coated) which started from one end of the tuber, radiating to the centre and later to the entire portion, along with shrinkage and mummification, may be due to the dry rot caused by organism <u>Diaporthe</u> <u>batatatis</u>. Chacko (1976) has reported similar symptoms of dry rot in stored sweet potato tuber. The brownish-black spots and hard texture on the outer skin of tubers kept as control (T_0), along with brown coloured internal portion which gradually lead to brittleness of the tuber may be the symptoms of black rot caused by organism Ceratocystis fimbriata. Similar signs of decay was reported in earlier study (Anon., 1959), as black rot disease. According to Padmaja (1985), the microbial disease named black rot brings considerable damage to stored sweet potato. The black coloured spores seen attached on tubers in T_0 and T_1 at the 60^{th} day of storage indicated symptoms of Aspergillus attack. Ray et al. (1993) isolated this fungus from decayed sweet potato tubers, stored at ambient temperature.

Among the various storage treatments tried, rotting was observed in three treatments alone. T_0 (control), T_1 (ordinary basket) and T_3 (mud coated) were kept in an almost exposed state and thereby more susceptible to decay. Even mud coating cannot act as a barrier to microbial invasion. This indicated that these three treatments are not suitable for prolonged storage of sweet potato on the basis of microbial decay. T_0 (control) and T_3 (mud coated) were suitable for one month storage, while T_1 was feasible upto 45 days of storage. Meantime, the results of T_7, T_6, T_5, T_4 and T_2 indicated storage feasibility, as no rotting was observed in these tubers even on the 60th day of storage (Plates 15 and 16).

4.1.4 Influence of storage treatments on sprouting on sweet potato

Sprouting is a primary storage problem which minimises the acceptability and suitability of sweet potato tuber. The effect of storage treatments on sprouting phenomenon of sweet potato at different durations was also evaluated to study the shelf life.

The storage treatment such as T_0 (control), T_1 (ordinary basket) and T_3 (mud coated) exhibited poor storage quality and were seen more prone to drying and rotting during the first month itself. But, the above three treatments were not subjected to sprouting and was mainly due to the faster depletion of moisture level and rotting by micro organisms. Low or high intensities of sprouting was observed in the other five treatments with time in storage.

In the present study, all the treatments

Plates 15 & 16. Sweet potato tubers on 60^{th} day of storage.


CARBON PAPER
60th DAY
CONTROL
COIR PITH.


PADDY HUSK
POLYTHENE COVERED
60th DAY
ORDINARY BASKET
MUD COATING

Plate 17. Sweet potato tubers stored in carbon paper and saw dust - view on 60^{th} day.

selected for storage were devoid of sprouting till the 15th day. And on the 30th day, sprout growth noticed was only on T_6 (polythene covered) which accounted nearly 25 per cent of tuber, while all the other four successful treatments (2, 4, 5 and 7) were free from sprout growth.

On the 45th day of storage, two treatments such as T_5 (coir pith) and T_7 (waste carbon paper) were free of sprouting, while varying degrees of sprouting was observed in three treatments such as T_6 (polythene covered), T_4 (paddy husk) and T_2 (saw dust). The magnitude of sprout growth in T_6 was increased significantly to about 50 per cent. The treatments 2 and 4 (saw dust and paddy husk) recorded minimum levels of sprouting (10 and 14 per cent respectively).

Data obtained on sprouting revealed that even on the 60th day, sprouting was totally absent in T_7, whereas the other four treatments were having sprout growth in varying intensities. The T_5 (coir pith) which was free from sprout growth till the 45th day, recorded 20 per cent sprouting on the 60th day of storage. Only slower rate of increase in sprouting was noticed in T_2 (saw dust) and T_4 (paddy husk) and came to 14 and 28 per cent respectively. A stagnation in sprout growth was noticed in T_6 and remained at 50 per cent, as observed on the 45th day of storage.

Results indicated that sprouting was observed only by a month's period of storage and that too was restricted to solely one treatment (T_6- polythene covered). And considering the lower level (25 per cent), tubers under this storage method cannot be marked unsatisfactory in storage quality. Four treatments namely sawdust, paddy husk, coir pith and waste carbon paper could be distinguished as highly recommendable for shelf life in favour of this aspect for 30 days. Compared to other treatments, earlier incidence of sprouting was observed in T_6, since sprout appeared from 30th day. And this was seen increased significantly on the 45th day of storage. Higher humidity and lesser ventilation level inside the polythene covers were the major causes for this change. According to Dayal and Sharma (1987), sprout growth was more pronounced at higher humidity. Bhatia et al. (1991) also reported similar results. Ajayi and Madueke (1990) reported that lower ventilation level also promotes sprouting of stored tubers.

Storage media namely coir pith (T_5) and waste carbon paper (T_7) were proved to be superior for 45 day's storage. The increased sprouting of T_6 (polythene covered) makes the tuber to be of lower quality for the succeeding days. But the incidence of sprout on T_2 (saw dust) and T_4 (paddy husk) at 10 and 14 per cent respectively, cannot be regarded as a barrier to storage quality. A possible explanation for this is the sudden and heavy rain, after the first month of storage, that raised rapidly the relative humidity of the storage room facing the interior back water at Vellayani. There could be every posssible chance for absorption of moisture by storage media. Hence, in these two treatments (saw dust and paddy husk) also, sprout growth appeared at a lower level by a period of45 days. According to Bhatia et al. (1991), presence of moisture content is always conducive to better sprouting.

The sprout growth in T_2 (saw dust) was progressing only at a slow rate and rose to 14 per cent at the end of storage period. The superiority in preventing sprouting phenomenon offered by coir pith was found less by 60th day, as more sprouting than saw dust has occured on the 60th day. Meantime, treatment 4 (paddy husk) doubled the percentage of sprouting from 45th day (14 per cent). This indicated that the respiration rate of tuber was higher when kept in paddy husk. Adesuyi (1973) reported a positive relationship between respiration rate and sprouting of tubers. Even though, initially the moisture content in media coir pith (9 per cent) and paddy husk (10 per cent) were slightly lesser than that of saw dust (11 per cent); the percentage of sprouting recorded in these two treatments were higher compared to saw dust on the 60th day. This also showed that the respiration rate of tubers kept in saw dust was lesser than that of samples in paddy husk and coir pith. Therefore, the saw dust media could minimise the respiration rate, than coir pith and paddy husk could do, when the storage experiment was progressed to 60 days.

Compared to all the storage treatments tried in this study, the T_7 (waste carbon paper) proved as the best one for storage of sweet potato, with regard to sprouting. Sprout growth was totally absent in this treatment throughout the entire period of study. This is because that the carbon paper covering allowed only limited rate of respiration of tubers when stored in it. This also indicated that carbon paper proved to be the best in hindering sprouting of tubers, even when stored during rainy season. Saw dust stood as the next superior medium. Coir pith and paddy husk followed the above media to be preferred as satisfactory methods.

4.1.5 Other physical changes associated with deterioration in quality of sweet potato tubers stored under different methods

Shrivelling, softness and dullness were the other physical changes associated with deterioration in quality of sweet potato tubers during storage.

On the 15th day of storage, fresh appearance of the tubers were retained in all the treatments except in T_3 (mud coated) and T_0 (control); which showed evident changes in external appearance of tubers. There was prominant wrinkles and shrivelling on the tuber skin of treatment 3 (mud coated), while shrivelling and softness of tuber skin was noticed in T_0 (control).

The shrivelling of T_3 (mud coated) and shrivelling and softness of T_0 (control) were significantly increased on the 30^{th} day of storage. The internal flesh of T_0 (control), appeared brownish in colour when cut opened. In all the other 6 treatments, stored tubers were having good appearance, even on the 30^{th} day.

The appearance of the skin when observed on the 45^{th} day showed only slight fading in colour than its fresh look in all the treatments except T_3 (mud coated) and T_0 (control) on the 30^{th} day of storage. However, the treatments - T_3 (mud coated) and T_0 (control), that already exhibited external and internal changes from the initial observation itself, showed marked deteriorative changes on the 45^{th} day. T_3 (mud coated) was observed with higher incidence of softness and shrivelling of tuber skin, and T_0 (control) recorded the maximum shrivelling and dullness with a hard woody texture of the tuber. The tubers in ordinary basket (T_1) which showed stability in freshness upto 30th day, recorded slight shrivelling on the tuber skin.

Even on the 60th day of storage, five treatments under experiment possessed fairly good external appearance for tuber. The deteriorative changes of T_0, T_1 and T_3 were rapidly increased and these three treatments suffered from maximum dullness on the 60th day. Meanwhile, only a general dullness of the tuber skin observed in the five treatments such as T_2 (saw dust), T_4 (paddy husk), T_5 (coir pith), T_6 (polythene covered) and T_7 (waste carbon paper) on the final observation. Regardless of the extent of other internal damage, these five media made no marked dehydration or noticeable changes in external surface such as shrivelling or softness; on the 60th day of storage.

The result revealed that six of the treatments studied could maintain a satisfactory appearance upto the 30^{th} day, while in the remaining two treatments - T_0 (control) and T_3 (mud coated), unappealing external look was noted from the 15^{th} day itself. According to Data and Eronico (1987), shrivelling is a common problem associated with storage of sweet potato. In the present study, only three treatments (control, ordinary basket, mud coated) were suffered from the problem of shrivelling before the study period was over. The shrivelling and softness of tuber skin was due to the dehydration of the tuber. The tubers stored in baskets (T_1) recorded shrivelling only on the 45^{th} day proving that, this treatment was resistant to dehydration upto the 30^{th} day of storage.

The loss of moisture content from the tuber was the main reason for the dehydration occured in T_0 (control), T_3 (mud coated) and T_1 (ordinary basket). According to Padmaja (1985), loss of moisture content leads to dehydration of stored tubers. Maximum dehydration was recorded in the above three treatments on the 60^{th} day of storage, especially on the control (T_0), where excessive dehydration was noticed. Rajamma (1984) also observed similar results on sweet potato kept exposed for 60 days.

Presence of moisture in the storage media is a preventive factor against dehydration of tuber, provided the media is not wet or soaking, as it leads to spoilage (Balagopal and Padmaja, 1985 and Ghosh et al. 1988). In a storage trial conducted by Rajamma (1984), the sweet potato tuber kept in sawdust was found suffered from dehydration after 30 days of storage. But in the present study, sawdust with 11 per cent moisture was found to prevent dehydration of stored tubers upto 60 days. Moist saw dust has been reported in earlier studies as an effective medium to keep sweet potato tuber in good condition (Anon., 1991). Similar effectiveness for prevention of dehydration of tuber was observed in coir pith with 9 per cent moisture and paddy husk of 10 per cent moisture.

The tubers kept in polythene covers (T_6) and in waste carbon paper (T_7) were found totally unaffected by dehydration or shrivelling even on the 60^{th} day of storage. These two treatments were found highly resistant to dehydration of tuber. Carbon paper and polythene covering may not allow the water loss and easy transpiration of water from tubers when kept inside. Besides, saw dust, coir pith and paddy husk were also successful in limiting dehydration and shrinkage of tuber skin.

Among the seven treatments and control which were selected for the study under report, the tubers kept as control (T_0) was seen deteriorated after the 30^{th} day of storage. The tubers stored in baskets (T_1) and mud coated (T_3) could remain sound only upto the 45^{th} day's observation. Tubers in the remaining five treatments were acceptable in this respect until termination of the study. Hence, the deteriorated specimens such as T_0 (control), T_1 (ordinary basket) and T_3 (mud coated) were eliminated from further studies. Statistical analysis of the results of cooking characteristics, organoleptic qualities and nutritional composition were carried out only with the five treatments that outlived the entire period of study.

Studies pertaining to cooking characteristics, organoleptic qualities and nutritional composition were conducted in fresh tubers as well as in stored samples under five treatments for various durations of 15^{th} day, 30^{th} day, 45^{th} day and 60^{th} day of storage. Data on the above aspects belonging to the three treatments such as T_1 (ordinary basket), T_3 (mud coated) and T_0 (control); that are not included for further presentation are depicted in Appendices 6 and 7. Data related to the remaining five treatments such as T_2 (saw dust), T_4 (paddy husk), T_5 (coir pith), T_6 (polythene covered) and T_7 (waste carbon paper); that are selected for detailed study were statistically analysed and the abstract of the Anova on the statistically analysed data on cooking, organoleptic and nutritional qualities are depicted in Appendices 4 and 5.

4.2 Changes in cooking characteristics of sweet potato stored under different methods for different durations

Many foods including the root crops cannot be properly digested in their normal state and hence require cooking, to improve its palatability and digestability and also to ensure the safety of foods. The changes in major cooking characters denote the qualitative changes of the particular food material. Here, the changes in cooking characteristics due to storage was assessed by determining the optimum cooking time and apparent water absorption by the tubers before storage and after storing at varying intervals.

4.2.1 Influence of storage treatments on optimum cooking time of sweet potato tuber

The effect of storage treatments on the time taken for cooking sweet potato at different intervals is given in Table 3.

The results presented in Table 3 revealed that the various storage treatments had significant influence on the optimum cooking time of sweet potato. T_4 registered the significantly the highest optimum cooking time whereas T_6 recorded the lowest.

Among the different storage periods, it was observed that increasing storage time increased the optimum cooking time and storage upto 60th day recorded significantly the highest cooking time.

Table3. Effect of storage treatments on optimum cooking time of sweet potato at different durations (minutes)

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	26	28	32	36	30.50
T_4	28	30	33	38	32.25
T_5	26	28	32	36	30.50
T_6	26	26	27	32	27.75
T_7	26	27	30	34	29.25
Duration mean	26.40	27.80	30.80	35.20	

Ftest: Me.=31.929.** Pe.=221.286.** Me.xPe.=1.405.[NS]
CD: Me.=0.870 Pe.= 0.778 Me.xPe.=1.740.
T_2 = Sawdust. T_4 = Paddy husk. T_5 = Coir pith.
T_6 = Polythene covered. T_7 = Waste carbon paper.
Note:** = Significant at 1% level. NS = Not significant.
Cooking time of fresh sample (before storage) = 25 minutes.

An increasing trend in the cooking time of sweet potato was observed with the advancement in storage durations. On the 15th day of storage, cooking time did not vary among different treatments except in T_4 (paddy husk) and found no marked increase than the fresh state, in all the five treatments. The tubers kept in saw dust (T_2), coir pith (T_5), polythene covers (T_6) and waste carbon paper (T_7) were on par with a similar rate of increase (4 per cent) in cooking time. However, T_4 (paddy husk) showed higher increase (12 per cent) and was significantly different from other four treatments.

Corresponding increase was observed in all the treatments except in T_6 (polythene covered) which remained unchanged on the 30^{th} day and recorded the least increase (4 per cent). Longer cooking time was recorded in T_4 (20 per cent), followed by T_2 and T_5 (12 per cent each). Treatments 2 and 5 were found to be on par with no difference in cooking time. The tubers covered in waste carbon paper (T_7) was observed to take less time for cooking (8 per cent). The treatments 4 (paddy husk), 6 (polythene covered) and 7 (waste carbon paper) marked significant difference in their cooking time on the 30^{th} day.

Tubers stored in paddy husk (T_4) was observed with the maximum cooking time on the 45^{th} day, marking an increase to 32 per cent, followed by treatments 2 (saw dust) and 5 (coir pith); both being on par and showed an increase to 28 per cent. T_7 (waste carbon paper) recorded only 20 per cent increase in cooking time, followed by T_6 (8 per cent increase) which recorded the least cooking time, among the five treatments.

As the storage period advanced to 45 and 60 days, the cooking time was also found to increase for all the five treatments. Observation on 60th day showed significant increase in the rate and was in line with the previous observations. 52 per cent increase in cooking time was noted in T_4 (paddy husk), which recorded the maximum cooking time, followed by treatments 2 (saw dust) and 5 (coir pith) (44 per cent). T_7 (waste carbon paper) recorded only 36 per cent increase, followed by T_6 (polythene covered) which showed the least increase (28 per cent).

According to Prema and Chellammal (1986), the cooking time of cassava tubers was observed to increase, as the storage period advanced. Booth (1973) also reported that longer period was required to soften roots when cooked after storage than normally required for the fresh tuber. Results of the present study also indicated that sweet potato required more time to get cooked to an optimum level after storage. This can be attributed to the increased toughness of the tuber flesh caused by drying of the tuber on prolonged storage. The data also showed that the tubers that was more affected by dehydration such as T_4 (paddy husk) recorded the higher rate of increase in cooking time at each storage intervals. And those tubers which were less affected by dehydration such as T_2 (saw dust) and T_5 (coir pith) performed better and observed only lesser increase of time. More supporting results were evident from treatments 6 (polythene covered) and 7 (waste carbon paper) which were unaffected by dehydration, because in these tubers lowest cooking time was observed after storage. Polythene covered sample (T_6) that preserved the maximum percentage of moisture of tuber exhibited minimum cooking time on all the storage durations with a stagnation on the 30th day.

Therefore, the above result proved polythene covered tubers (T_6) to be superior, followed by waste carbon paper (T_7) in limiting the rate of increase in cooking time due to storage. Tubers in coir pith (T_5) and in saw dust (T_2) also possessed good results with regard to the optimum cooking time of tubers.

4.2.2 Influence of storage treatments on apparent water absorption of optimum cooked sweet potato

Apparent water uptake is the weight of moisture absorbed by the tubers during cooking. The effect of storage treatments on the water absorption rate of sweet potato cooked at optimum level is presented in Table 4.

Table 4. Effect of storage treatments on apparent water absorption of sweet potato cooked at optimum level (per cent)

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	48.70	47.40	44.65	41.90	45.663
T_4	47.95	46.80	44.15	40.75	44.913
T_5	48.75	47.41	44.80	42.10	45.762
T_6	49.30	49.10	47.95	44.65	47.750
T_7	49.10	48.15	46.40	43.15	46.700
Duration mean	48.76	47.77	45.59	42.51	

F test: Me.=3496.429.** Pe.=28037.140.**
Me.x Pe.=213.571.**
CD : Me. = 0.054. Pe. = 0.049. Me.x Pe. = 0.109.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Water absorption of freshly harvested sweet potato = 50% .

The apparent water absorption of cooked sweet potato showed significant variation among storage treatments and storage period. Water absorption of cooked sweet potato tubers was less affected by storage in polythene covers (T_6) and T_6 recorded significantly higher water absorption (47.75). The lowest apparent water absorption was registered by T_4 (44.913). Increasing the storage time significantly reduced the apparent water absorption from 49.10 to 43.15.

Among the combinations, storage in the different media upto 30 days did not cause any variation in apparent water absorption, whereas storage in T_4 for 60 days drastically reduced the apparent water absorption to 40.75.

From Table 4, it is evident that storage causes a significant decrease in water absorption rate of sweet potato during cooking. With regard to water uptake, when cooked on the 15^{th} day of storage, there was only a marginal reduction in T_6 (polythene covered); the value being 49.3 per cent as against 50 per cent for fresh sample. This was followed by T_7 (waste carbon paper) which recorded 49.1 per cent, T_5 (coir pith) 48.75 per cent and T_2 (saw dust) with 48.70 per cent. The lowest water absorption rate was observed in T_4 (paddy husk) at 47.95 per cent. T_2 (saw dust) and T_5 (coir pith) were on par on the 15th and 30h days of storage.

The rate of water absorption on the forth coming observation followed a progressive decrease similar to 15th day, in all the five treatments. The values ranged from 49.1 to 46.8 per cent on 30th day and from 47.95 to 44.15 per cent on the 45th day.

When the sweet potato was cooked to optimum on 60th day of storage, the rate of decrease in water absorption was found least in T_6 (10 per cent), followed by T_7 (waste carbon paper) which recorded 13 per cent decrease, from that of the freshly harvested stage. Treatment 5 (coir pith) showed 15 percent decrease, while T_2 (saw dust) recorded 16 per cent decrease in apparent water absorption. Rate of decrease was maximum in T_4 (18 per cent) on the 60th day.

The rate of water absorption while cooking was found to be decreased linearly with the increase in storage time of sweet potato, in the present investigation. However, in certain treatments the difference was very minute in comparision with tubers prior to storage. The lesser water absorption capacity on storage was perhaps due to the aggregation of starch granules together on storage and become hard enough to absorb water sufficiently into the tubers. Treatments that proved to be better in retaining the initial moisture content and preventing the moisture loss on prolonged storage (T_6 and T_7) could absorb more water when cooked. When the skin and tuber gets dried up on storage, the constituents become hard, which ultimately affects the semi permeability of the tuber skin to water leading to lesser water absorption. Deterioration in cooking quality has been reported in certain species of stored yam, where the proximal portion of the tuber tend to be hard after cooking (Sundaresan et al. 1991). In the present study, cooking characters of all the five treatments were not affected by significant deterioration of quality of tubers. Even the tubers in T_4 (paddy husk) which secured the least values was having acceptable results in cooking character relating to water absorption. Tubers stored in saw dust (T_2) and coir pith (T_5) obtained good results. The treatments 6 and 7 proved as best methods based on water absorption capacity of tubers.

4.3 Changes in organoleptic qualities and overall acceptability of sweet potato cooked after storage

Food materials like roots and tubers are subject to changes in quality on storage. Quality is the composite of characteristics which have significance in determining the degree of acceptability of that substance. One of the parameters which determines quality is consumer acceptability which needs to be tested. Hence, influence of storage on the organoleptic quality of sweet potato was measured through sensory evaluation tests of fresh and stored samples after cooking. Appearance, colour, taste, flavour, texture and doneness; the various quality attributes were rated on a five point scale. The overall acceptability was worked out by adding the mean scores obtained for the six quality attributes tested. The most acceptable in each criteria was given a score of "4" and the least accepted was given a score of "0". As the number of judges were ten, the maximum mean score that could be obtained for a sample was "4" and minimum "0".

Changes in quality attributes were assessed on cooking fresh as well as stored samples at different durations and the results are depicted below.

4.3.1 Influence of storage treatments on appearance of cooked sweet potato

Appearance is a visual property of food, including size, shape, colour and conformation. The general appearance of sweet potato tubers stored using various methods was assessed after cooking and the mean scores are depicted in Table 5.

Results presented in Table 5 showed significant variation of storage treatments and period on the appearance of cooked tubers. T_7 recorded the highest score of 4.00 which is significantly superior to all other storage treatments. T_6 recorded the lowest score of 2.9.

Table 5. Influence of storage treatments on the appearance of cooked tuber at different durations (mean score)

Number of panel members = 10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	4.00	4.00	3.90	3.70	3.90
T_4	4.00	4.00	3.80	2.30	3.52
T_5	4.00	4.00	3.15	2.20	3.34
T_6	4.00	4.00	2.90	0.70	2.90
T_7	4.00	4.00	4.00	4.00	4.00
Duration mean	4.00	4.00	3.55	2.58	

F test:Me.=633.398.** Pe.=1792.896.** Me.x Pe.=322.068.**
CD Me.= 0.016. Pe. = 0.015. Me.x Pe. = 0.033.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.

T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1 % level. Mean score secured for fresh sample (before storage) = 4.00. Maximum mean score = 4.00.

Storing the tubers upto 30 days had no influence on the score whereas storage upto 60 days registered the lowest score value of 2.58.

Among the combinations, all the storage treatments upto 30 days and storage in T_7 upto 60 days were on par and significantly superior to other combinations. Storage in T_6 upto 60 days registered significantly the lowest value.

In the case of general appearance, the cent percent score obtained for the sweet potato before storage was maintained by all the five treatments upto the 30thday, the appearance being rated to be superior. Treatment 7 (waste carbon paper) obtained maximum highest score (4) on appearance during the entire period of the study.

On the 45th day, T_2 (saw dust) recorded only a negligible reduction in score (2.5 per cent) followed by T_4 (5 per cent). The reduction in score obtained for T_5 (coir pith) was 21.25 per cent, followed by T_6 (polythene covered) with 27.5 per cent reduction, which recorded the least score for appearance.

Storage of the tubers for 60 days emphasized that best score for appearance was maintained by T_7

(waste carbon paper). Next in ranking order was T_2 which maintained 92.5 per cent of the initial score for appearance, followed by T_4 (57.5 per cent), T_5 (55 per cent) and lastly T_6 which scored a significantly diminished value (17.5 per cent).

In an earlier study conducted by Prema and Chellammal (1986), the appearance of cassava tubers stored in one and a half inches soil column were found diminished, when cooked after 14th day. But the results of the present study makes it evident that all the five samples of sweet potato could remain with the best score for appearance, upto 30 days of storage. Besides, tubers in T_7 (waste carbon paper) scored highest for appearance, on 45th and 60th days. This favourable result, obtained, was mainly due to the absence of weevil damage on all the five treatments upto 30 days and on T_7 (waste carbon paper) throughout the study. Eventhough, there was initial stages of weevil entrance on T_6 (polythene covered) at the 30th day, this was not found to affect the general appearance of the cooked sample. The slight reduction in score of T_2 (saw dust) on the 45th day may be due to the incidence of sprout growth in the above treatment. In T_4 (paddy husk) and T_5 (coir pith), the diminished score on 45th day can be accounted to the incidence of weevil damage in the stored tubers. There was a sudden decrease in the appearance score of T_4 (paddy husk) on the 60th day of storage. The tubers kept in T_6 (polythene covers) also showed a steady decrease in score on 45th and 60th days. The diminished value scored for appearance by T_4(paddy husk) and T_6(polythene covered) was due to the increased percent of weevil attack and sprouting on these storage treatments. In general, in all the treatments, except in T_6 (polythene covered) had acceptable appearance upto 60 days. In appearance score, T_7 (waste carbon paper) along with T_2 (saw dust) .pl 57 maintained the superior score.

4.3.2 Influence of storage treatments on the colour of stored sweet potato after cooking

Colour is powerfully associated with the food quality and is commonly an index of ripeness or spoilage, which is one of the criteria that helps to determine the quality. The effect of storage using locally available materials on the colour of sweet potato at the four durations of study is presented in Table 6.

Table 6. Influence of storage treatments on the colour of cooked tuber at different durations (mean score)

Number of panel members = 10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	4.00	4.00	3.80	3.20	3.75
T_4	4.00	4.00	4.00	1.20	3.30
T_5	4.00	4.00	2.95	2.60	3.39
T_6	4.00	4.00	3.60	0.90	3.12
T_7	4.00	4.00	4.00	3.20	3.80
Duration mean	4.00	4.00	3.67	2.22	

F test: Me.=273.602.** Pe.=2885.703.** Me.x Pe.=282.533.**
CD: Me. = 0.016. Pe. = 0.015. Me.x Pe. = 0.033.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Mean score for colour of cooked sample before storage = 4.00. Maximum mean score=4.00.

Table 6 elucidates that the different storage media and storage intervals had significant influence on the colour of cooked sweet potato tubers. T_7 recorded the highest mean value of 3.8 while T_6 registered the lowest mean value (3.125).

As in appearance, colour of cooked tubers showed reduction in the mean values after 30 days of storage and the lowest value being recorded by T_6 at 60^{th} day (0.9) which is significantly inferior to all other combinations.

Various storage treatments administered were found to retain the colour of sweet potato, comparable to that of fresh tuber, for all the five treatments up to the 30^{th} day of storage, obtaining the maximum mean score of 4.

Even on the 45 th day of storage, the tubers kept in waste carbon paper (T_7) and in paddy husk (T_4) could maintain the maximum score for colour. The tubers stored in saw dust (T_2) and in polythene covers (T_6) also obtained favourable results, as the colour of T_2 (saw dust) showed only a slight decrease of 5 per cent, followed by T_6 (10 per cent). Treatment 5 (coir pith) scored comparatively less for colour; eventhough the score obtained was found satisfactory (73 per cent).

The observations on the 60th day indicated that T_7 (waste carbon paper) continued to remain with the highest score with respect to colour and was on par with T_2 (saw dust); both getting 80 per cent score. The T_5 (coir pith) was found to maintain 65 per cent of the score on the 60th day of storage. Though, maximum score was maintained upto the 45 days, the T_4 (paddy husk) showed a significantly lower acceptability for colour by the 60th day. When comparing the five treatments, T_4 (paddy husk) and T_6 (polythene covered) showed a significantly lower acceptability score for colour, having 30 and 22 per cent score respectively; the T_6 obtained the lowest score on the 60^{th} day.

Studies conducted in cassava using different depths of soil column indicated that the score for colour of the tubers were observed to diminish in all samples after 21 days of storage (Prema and Chellammal, 1986). More promising results were obtained in the present study, as the colour of the cooked sweet potato remained highly acceptable upto 30 days in all the samples. The low incidence or absence of insect damage during the initial month was contributing to this results and thereby the tuber quality was not altered. The score for colour of treatments 4 (paddy husk) and 7 (waste carbon paper) were superior and maximum till 45 days, but drastically reduced to 1.2 in T_4 (paddy husk) by the 60^{th} day. This reduction might be due to the sudden increase of the weevil attack on the tuber. The brownish-black colour on the tuber leading to a significantly lower value of polythene covered tubers (T_6) at 60^{th} day can also be accounted to the same reason. Increase in storage duration also caused a reduction in score for colour of tuber flesh in treatments 2 (saw dust) and 5 (coir pith); where the initial deep yellowish colour was changed to pale yellow. Generally, all the treatments gave acceptable colour to the cooked sweet potato upto the 45^{th} day and the score were found satisfactory in treatments 2 (saw dust), 5 (coir pith) and 7 (waste carbon paper) till the 60^{th} day. Among these treatments, T_7 (waste carbon paper) and T_2 (saw dust) proved to be the best acceptable treatments with respect to colour of the cooked tuber.

4.3.3 Influence of storage treatments on taste of cooked sweet potato

Taste is not only a sensory response but also an aesthetic appreciation of the mouth towards soluble materials. Taste is the major attribute which determines the acceptability of a food material. Kawabata <u>et al.</u>

(1984) found that sugar content of sweet potato was increased by boiling. This increase is brought about by the hydrolysis of starch in the tuber (Lila,1988). Boiling, thereby helps to improve the taste of tuber. Thus the effect of storage treatments on the taste of sweet potato was measured after cooking and the mean scores are presented in Table 7.

The data depicted in Table 7 revealed that storage treatments and durations significantly influence the taste of cooked tubers. T_2 was observed to be the best with a mean value of 3.362; while T_6 was found to be significantly inferior (2.375).

The taste of tuber was significantly reduced with increase in storage time, the minimum being registered by T_6 at 60^{th} day of storage.

Table 7. Influence of storage treatments on the taste of cooked tuber at different durations (mean score)

Number of panel members = 10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	3.00	3.00	3.45	4.00	3.362
T_4	3.00	3.00	3.60	1.90	2.875
T_5	3.00	3.00	3.80	2.50	3.075
T_6	3.00	3.50	3.00	0.00	2.375
T_7	3.00	3.00	3.20	3.40	3.150
Duration mean	3.00	3.10	3.41	2.36	

F test: Me.= 448.398.** Pe.= 77.796.** Me.x Pe.= 528.801.**
CD: Me.= 0.016. Pe. = 0.015. Me.x Pe. = 0.033.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.

T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Mean score secured for sample cooked before storage=3.00. Maximum mean score = 4.00.

In the case of taste, it was noticeable that the mean score secured prior to storage was only 3 (75 per cent). Ghosh et al.(1988) indicated that the sweet potato tuber usually tasted less sweet at freshly harvested stage.

All the treatments carried the same mean score, when taste was assessed on the 15^{th} day, thus signifying the stability in taste. Except T_6 (polythene covered), tubers stored in the other four media continued to retain score for taste upto 30 days. Whereas T_6 gave an improvement in score by a rise to 87 per cent.

Next observation on 45^{th} day was reciprocal to the 30^{th} day's result, as the taste of T_6 (polythene covered) was reduced, whereas the other four treatments showed an improvement in taste. Treatment 6 exhibited a lower score (75 per cent) attaining a reversion in taste quality to the 15^{th} day's level, thus recording the least score on 45^{ht} day. T_5 (coir pith) recorded highest score for taste (95 per cent), followed by T_4 (paddy husk) with 90 per cent score. Tubers stored in saw dust (T_2) and in waste carbon paper (T_7) recorded 86 and 80 per cent scores respectively on the 45^{th} day.

Evaluation on 60^{th} day indicated much variation in taste of the stored tubers. The score value of T_2 (saw dust) and T_7 (waste carbon paper) had been further enhanced expressing much more acceptability in this sensory quality than all the previous spells of observation. At the same time, the other three treatments such as T_4 (paddy husk), T_5 (coir pith) and T_6 (polythene covered) possessed a lower score. The maximum possible score was secured by T_2 (100 per cent), followed by T_7 (waste carbon paper), improving its score to 85 per cent. Even when the taste was lessened, T_5 (coir pith) could maintain 62 per cent score followed by T_4 (paddy husk) that recorded 47 per cent. Taste of T_6 (polythene covered) was observed to be highly inferior, as it secured a nil score on the 60^{th} day.

In a study with cassava, Prema and Chellammal (1986) observed that the score for taste was diminished after 14 days when stored in soil column. In the present investigation, the taste of sweet potato was found to be increasing by 30 days of storage in T_6, and by 45th day in all the other treatments. As revealed in the results, the lower score obtained by sweet potato before storage was due to the lesser sugar content of the tuber just after harvest, as reported by Maini (1976) and Ghosh <u>et al</u>. (1988). This showed that the taste of sweet potato is highly associated with the sugar content. The increased taste of polythene covered tubers (T_6) on 30th day indicated that storing in polythene cover enhances the sugar content by 30 days of storage. Balagopal and Padmaja (1985) found that increased sugar content makes the tuber more palatable.

By 45th day, remaining four treatments exhibited a higher score than at the freshly harvested state for taste, probably because of higher sugar concentration in the tubers. Mean while, an improvement in taste, noticed in T_6 (polythene covered) was not retained during this period. Reducing sugar content was also found diminished in the tubers stored by this treatment at this same period. This reduction might be due to the higher incidence of sprout on the tuber on 45th day of storage. Sprouting reduces the starch and sugar in the tuber, as reported by Lila and Nambisan (1991).

For taste of the two samples - T_2 (saw dust) and T_7 (waste carbon paper); higher score was obtained on the 60th day than in fresh tubers. This indicates that by these methods the sweet potato can be stored for longer durations. Sprouting together with weevil attack affected treatments 4 (paddy husk), 5 (coir pith) and 6 (polythene covered) on the 60th day to perform a decreasing score value for taste. The bitter taste formed on the tuber due to higher weevil damage was the cause of complete loss of taste in polythene covered tubers(T_6) on the 60th day. Padmaja and Rajamma (1982) also obtained a similar finding to this result as weevil infested tubers developed a bitter taste and thereby found unfit for consumption.

Sweet potato stored in polythene covers (T_6) had secured highest score for taste on the 30th day, whereas treatments 4 (paddy husk) and 5 (coir pith) obtained highest score for taste on 45th day. For prolonged storage upto 60 days, tubers stored in saw dust secured highest score for taste, followed by T_7 (waste carbon paper) which also was superior, with respect to taste of cooked tubers.

4.3.4 Influence of storage treatments on flavour of sweet potato after cooking

Flavour is the mingled but unitary experience of sensation produced by a material taken in the mouth, percieved principally by the senses of taste, smell and by other cutaneous sensations in the mouth. A diverging range of flavour was observed in different breeds of sweet potato (Horvat et al. 1991). The tuber taken in the present study possessed a very good flavour when cooked fresh (before storage). So the effect of storage treatments on the flavour of sweet potato was assessed after cooking and the mean score obtained are given in Table 8.

Table 8. Influence of storage treatments on the flavour of cooked tuber at different durations (mean score)

Number of panel members = 10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	4.00	4.00	2.80	2.00	3.20
T_4	4.00	4.00	2.30	1.90	3.05
T_5	4.00	4.00	2.05	1.80	2.96
T_6	4.00	4.00	1.95	0	2.47
T_7	4.00	4.00	2.90	2.10	3.25
Duration mean	4.00	4.00	2.40	1.56	

F test: Me.= 147.426.** Pe.= 2955.469.** Me.x Pe.= 78.758.**
CD: Me.= 0.023. Pe. = 0.021. Me.x Pe. = 0.046.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.
Note: ** = Significant at 1% level. Mean score secured for sample cooked before storage=4.00. Maximum mean score=4.00.

The different storage media and storage period significantly influenced the flavour of cooked sweet potato as evident from the Table 8. T_7 registered the highest mean value of 3.25 closely followed by T_2 (3.20).

Similar to other characters, increase in storage period beyond 30 days reduced the flavour and T_6 at 60th day had the lowest mean value of 0.

The flavour of various treatments remained superior securing the cent per cent score upto 30 days. Score values revealed that as the storage period advanced from 30 days, flavour quality was found to be decreasing and this linear trend was seen until the 60th day. A significant difference was observed in the score for flavour of cooked sweet potato after 30 days of storage.

Even though, lower score was obtained for all the treatments on the 45th day, retention of flavour was higher in T_7 (waste carbon paper) which secured 72 per cent score, followed by T_2 (saw dust) with 70 per cent score. The tubers stored in paddy husk (T_4) were found to maintain 57 per cent score for flavour, followed by T_5 (coir pith) which obtained 51 per cent score. The lowest score was recorded for stored sweet potato in T_6

(polythene covered), which was able to obtain only 48 per cent score for flavour.

Increased rate of flavour loss was observed on the 60th day of storage of sweet potato. However, tubers stored in T_7 secured a highest score (52 per cent), followed under T_2 (saw dust) which obtained 50 per cent score. The scores maintained by treatments 4 (paddy husk) and 5 (coir pith) were 47 and 45 per cent respectively, whereas in T_6 (polythene covered), the flavour loss was much pronounced and found not acceptable since the score was "zero" on the 60th day of storage.

From the result, it could be seen that the higher score for flavour that existed in all the treatments, showed a steady loss after 30th day of storage. An intensified loss of flavour was observed in T_6 on the 45th day. Higher accumulation of carbon dioxide inside the polythene covers as a result of increased respiration rate, due to greater sprouting may be the reason for this considerable flavour loss of T_6 (polythene covered). According to Padmaja (1985), loss of flavour results when sweet potato is stored at less than 7 per cent oxygen.

Later on the 60th day, the polythene covered tuber (T_6) was significantly affected by weevil attack also and this led to the formation of off flavour in the tubers, which resulted in a "0" score value for flavour. Though not to a greater extent, the flavour of sweet potato stored by saw dust (T_2), paddy husk (T_4) and coir pith (T_5) were also affected by the occurence of sprouting on the 60th day. Ultimately, it was found difficult to preserve the orginal flavour of sweet potato during prolonged storage. However, when stored in saw dust (T_2) and waste carbon paper (T_7), the flavour loss could be limited to a certain extent. These treatments maintained 50 to 52 per cent score on the 60th day. Therefore, waste carbon paper and saw dust were concluded to be the satisfactory treatments to minimize the loss of flavour for prolonged storage upto two months.

4.3.5 Influence of storage treatments on texture of cooked sweet potato

Texture constitute a physical property of food stuff, apprehended both by the eyes and the skin and muscle senses located in the mouth. This property on the cooked sweet potato tuber was studied. Table 9 gives the data obtained for texture effect by different storage treatments.

The data presented in Table 9 elucidates that different storage spells had no significant effect on the texture of cooked tuber. T_7 was observed to be the best with a mean value of 3.625; closely followed by T_2 (3.575). T_6 recorded the lowest value (3.175).

Among the combinations, storage in different media upto 30 days did not cause any variation in texture, while beyond 30 days, the score was reduced and registered the value of 2.38 on the 60^{th} day.

Table 9. Influence of storage treatments on the texture of cooked tuber at different durations (mean score)

Number of panel members =10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	4.00	4.00	3.50	2.80	3.575
T_4	4.00	4.00	2.70	2.20	3.225
T_5	4.00	4.00	2.90	2.10	3.250
T_6	4.00	4.00	2.70	2.00	3.175
T_7	4.00	4.00	3.70	2.80	3.625
Duration mean	4.00	4.00	3.10	2.38	

F test: Me.= 148.602.^{NS} Pe.=2479.302.** Me.x Pe.=49.999.^{NS}
CD: Me.= 0.016. Pe.= 0.015. Me.x Pe.= 0.033.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.

T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. NS = Not significant.
Mean score for sample cooked before storage = 4.00.
Maximum mean score = 4.00.

When the samples were assessed on various storage intervals, it was indeed happy to note that the texture of all the five treatments scored maximum (4) upto 30th day. Treatment 7 (waste carbon paper) scored highest on the 45th day (3.7) with only a marginal decrease in score (8 per cent), followed by T_2 (saw dust) which showed only 13 per cent reduction in score. The tubers stored in coir pith (T_5) recorded 28 per cent reduction in score, whereas T_4 (paddy husk) and T_6 (polythene covered) obtained the least score and both marked 33 per cent decrease in score and was statistically at par during the period.

Data on the 60th day also showed the same trend of decrease. However, higher and preferable score was recorded in treatments 7 (waste carbon paper) and 2 (saw dust) both having similar scores with only 30 per cent reduction. In treatments 4 (paddy husk) and 5 (coir pith), sweet potato recorded moderate score for texture (55 and 52 per cent respectively); whereas T_6 (polythene covered) scored 50 per cent on the 60th day for texture.

These results from the present study proved that storage of sweet potato using different treatments showed less effect on the texture of cooked tuber. The results of the study in cassava tuber by Booth (1973) indicated that the texture of tuber which was found extremely softened internally during prolonged storage, could frequently regain an acceptable texture by cooking. According to Prema and Chellammal (1986), the texture of cassava tubers stored at different depths of soil column showed a decrease in score from 14th day onwards. In the present trial, a highly acceptable soft texture was noticed in cooked tubers of all the treatments upto 30 days and the score obtained was maximum at this period. But, 45th day onwards, the score was found lowered in all the treatments. This was due to the change in texture, which turned to be more sticky during the advanced storage period. The stickiness of the tuber flesh was found again increased, when cooked on the 60th day of storage, thereby causing considerable reduction in score.

Along with the other qualities which performed superior results in T_7 and T_2, the texture of cooked tuber also was exhibited with higher range of score when stored upto 60 days. The other three treatments (T_5, T_4 and T_6) were satisfactory in favour of texture.

4.3.6 Influence of storage treatments on doneness of sweet potato

Doneness is a quality which determines the cooking ability of the food stuff. The effect of storage treatments pertaining to the quality attribute "doneness" at different durations was measured and the mean scores obtained are given in Table 10.

Analysis of results on doneness of cooked tuber (Table 10) revealed that T_7 registered significantly the highest mean value of 3.95, whereas T_6 registered the lowest value.

Table 10. Influence of storage treatments on the doneness of tuber at different durations (mean score)

Number of panel members = 10.

Storage treatments	STORAGE DAYS				Treatment mean
	15	30	45	60	
T_2	4.00	4.00	3.70	3.50	3.800
T_4	4.00	4.00	3.90	2.80	3.675
T_5	4.00	4.00	3.80	2.70	3.625
T_6	4.00	4.00	3.25	1.60	3.212
T_7	4.00	4.00	4.00	3.80	3.950
Duration mean	4.00	4.00	3.73	2.88	

F test: Me.= 244.102.** Pe.= 1125.703.** Me.x Pe.= 135.033.**
CD: Me.= 0.016. Pe.= 0.015. Me.xPe.= 0.033.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Mean score obtained for sample cooked before storage=4.00. Maximum mean score=4.00.

Storage after 30 days reduced the value for doneness significantly and T_6 at 60^{th} day registered the lowest value (1.6).

When observed on the various storage durations, it was seen that all the five samples upto 30 days possessed maximum score for doneness, similar to that of the freshly harvested tuber. It was promising to find that even on the 45th day of storage, sweet potato stored in waste carbon paper (T_7) secured the cent per cent score for doneness, competing with the performance of very fresh tuber. The results of T_4 (paddy husk), T_5 (coir pith) and T_2 (saw dust) were also welcoming, as they showed only slight variation in their scores. Sweet potato under T_4 (paddy husk) maintained 97 per cent of score followed by T_5 (95 per cent) and T_2 (92 per cent). It was exciting that even the lowest score that recorded by T_6 (polythene covered) was above 80 per cent on the 45th day. This meant the feasibility of these storage methods with less fear of being acceptable doneness wise for a storage period of 45 days.

While on the 60th day, the treatment 7 (waste carbon paper) retained the highest score for doneness (95 per cent) and the decrease was found to be negligible. By this day, T_2 secured 87 per cent of score and became superior to T_4 which recorded 70 per cent score, followed by T_5 (65 per cent). The least score for doneness was noticed in T_6, which was 40 per cent.

Prema and Chellammal (1986) indicated that doneness of cassava tubers after storage in soil column decreased by 14th day. While in the present trial with sweet potato, doneness was found unaffected upto 30 days of storage. This may be due to the lesser or absence of deteriorative changes during the first month of storage. But, by prolonged storage, the starch granules were subjected to dehydration and thereby resisted to cook well as that of freshly harvested condition. That was why, the score for doneness indicated a reduction after 30th day of storage. Microbial attack was another factor which influenced the doneness of tuber in the present study. The treatments which were attacked by weevil such as T_6 (polythene covered), T_4 (paddy husk) and T_5 (coir pith) showed significant decrease in score for doneness. However, the decrease in score for doneness with increased storage period was minimum in this study. Among all the treatments studied, T_7 (waste carbon paper) and T_2 (saw dust) proved to be best for storage with regard to the doneness of tuber.

4.3.7 Influence of storage treatments on the overall acceptability of cooked sweet potato

The fate of a food product has always rested on acceptance by the consuming group. Hence, it was thought of interest to further ascertain the overall acceptability of cooked sweet potato at different durations of storage. Preference depends not only on a particular character examined, but also on every quality involved in the evaluation. The positive trend obtained for the different sensory attributes enthused the investigation to work out the overall acceptability performed by tubers stored in various media. The overall acceptability was ascertained by computing the total score given for various quality parameters such as appearance, colour, taste, flavour, texture and doneness by panel members and also through ranking the total score. The results are depicted in Table 11.

The overall acceptability values presented in Table 11 indicated that T_7 was superior to other treatments in the overall acceptability and registered a value of 21.77. The lowest value was by T_6 (17.275).

Increasing storage period reduced the overall acceptability and the lowest value of 5.2 was registered by T_6 at 60^{th} day.

The sum total of all the score obtained for sweet potato cooked before storage was 23 (96 per cent); while the maximum possible score was computed to be 24. Maximum score could not be obtained by the fresh tubers when cooked, due to the lower score for taste performed at this time. These scores were compared with that of the total score obtained by the various treatments at particular intervals, over a period of 60 days. For all the five treatments, there was no change in the overall

Table 11. Influence of storage treatments on the overall acceptability of cooked tuber at different duratons (mean score)

Storage treatments	Storage days								Treatment mean of score
	15		30		45		60		
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	
T_2	23.00	4	23.00	4	21.15	4	19.20	4	21.597
T_4	23.00	4	23.00	4	20.30	4	12.30	1	19.600
T_5	23.00	4	23.00	4	18.65	3	13.90	1	19.637
T_6	23.00	4	23.50	4	17.50	3	5.20	0	17.275
T_7	23.00	4	23.00	4	21.80	4	19.30	4	21.775
Duration mean of score	23.00		23.10		19.86		13.98		

F test: Me.=1779.896.** Pe.=12193.140.** Me.x Pe.=1060.090.**
CD: Me.= 0.040. Pe.= 0.036. Me.x Pe.= 0.081.
T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.

T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Mean score obtained for sample cooked before storage = 23.00. Maximum mean score = 24.00. The method applied for ranking of score is presented in Appendix 3.

score (96 per cent) on the 15th day, thus acquiring a "very good" acceptability rank for the cooked tubers.

A close watch on the overall sensory performance by various treatments on the 30th day indicated that the score was increased to 98 per cent in T_6 (polythene covered) which recorded the highest acceptability for taste at this time accounted for the increase in score value. Hence, this treatment was found to be the most acceptable for a 30 day storage. Score for overall acceptability was seen steady in the other four treatments and remained in a "very good" acceptability rank even on 30th day. This disclosed the potentiality for recommending all the five treatments for storage of sweet potato over a period of 30 days on total acceptability rating.

All the five samples showed a tendency to lessen their scores for overall acceptability, when stored beyond 30 days. However, the rate of decrease was found very limited in certain treatments. Overall acceptability on 45th day gave T_7 (waste carbon paper) the superior position with 91 per cent score, closely followed by T_2

(saw dust) having 88 per cent score and T_4 (paddy husk) with 85 per cent score. T_5 (coir pith) also obtained a better score on overall acceptability, followed by T_6 (73 per cent). Deviating from the result obtained on the 30th day, T_6 was ranked lowest on 45th day, with respect to overall acceptability. The result on 45th day was exciting that treatments 7 (waste carbon paper), 2 (saw dust) and 4 (paddy husk) still ranked as "very good" and treatments 5 (coir pith) and 6 (polythene covered) were ranked "good" when their values for overall acceptability were considered. This favours the storage possibility of sweet potato using the different media under study upto 45th day, based on the rank for general acceptability.

The overall acceptability was found to be decreasing in all the treatments when assessed on the 60th day. The rate of decrease was more in treatment 6. However, superior score was noticed in T_2 (80 per cent). Significant reduction in score was marked in T_5 which maintained 58 per cent score, followed by T_4 which had 52 per cent score. The least acceptable was T_6 which obtained only 22 per cent score. The ranking revealed that treatments - 7 (waste carbon paper) and 2 (saw dust) were still having a very good acceptability, whereas T_4 (paddy husk) and T_5 (coir pith) were found "unsatisfactory" and T_6 (polythene covered) was ranked with "poor" acceptability on 60th day.

A general analysis of the score obtained for the various quality attributes revealed that, storage of sweet potato using all the five media could be useful upto 45 days and only two media could be successfully recommended for 60 days. The maximum score attained by the freshly harvested tuber was 96 per cent and the overall acceptability of all the five treatments revealed on the 15th day was similar and comparable with that of fresh sweet potato. Ghosh et al.(1988) revealed that, the taste of the tubers increased by extending the storage period. Similar finding was observed in T_6 (polythene covered) on the 30th day, as the score for taste was increased which was responsible to increase the overall acceptability score to 98 per cent. Such an upward trend would be a welcome pattern. The other four treatments (2,4,5 & 7) presented an increase in the score for taste on the 45th day, but the overall score could not be enhanced, because of the diminished score obtained for other quality attributes like appearance, colour, flavour, texture and doneness. The overall score was decreased in T_6 (polythene covered) and T_5 (coir pith) from 45th day, due to the low score for taste and other attributes studied. Weevil infestation of tuber negatively influenced these treatments to have a considerable loss of overall score. Since there was higher incidence of weevil damage in T_4 (paddy husk) also, during the later stage of second month of storage, the acceptability scores were also found significantly reduced beyond 45 days.

From the foregoing discussion on acceptibility, it is evident that all the treatments were highly accepted for a storage period of 30 days, making an exciting result by T_6 (polythene covered). The overall acceptability scores ranged from 91 to 73 per cent on the 45^{th} day. The lowest score for acceptability was recorded by T_6 (polythene covered) and still the ranking obtained for this was "good". However, this method was not found feasible beyond 45 days. Coir pith (T_5) and paddy husk (T_4) were also studied as less feasible media for 60 day's storage as they had only moderate overall acceptability (58 and 52 per cent).

Envisaging all sensory qualities assessed, the overall acceptability of stored sweet potato was maintained superior in T_7 (waste carbon paper), followed by T_2 (saw dust) having 81 and 80 per cent score respectively, during the prolonged storage of 60 days.

4.4 Changes in nutritional composition of sweet potato stored under different methods

The chemical composition of sweet potato varies widely according to cultivar, climatic conditions, degree of maturity and the duration of storage after harvesting. Various biochemical changes occur during storage of sweet potato. Hence, it was indispensable to review and find the variation in nutritional composition of stored sweet potato tubers. Maini (1976) reported that the rate and extent of change in starch and reducing sugar vary with the variety of tuber, temperature and humidity. The data on the nutritional parameters monitored such as moisture, starch and reducing sugar were statistically treated and the results are given below. The effect of storage treatments and durations on nutritional composition of sweet potato is illustrated in Figure 2.

4.4.1 Influence of storage treatments on moisture content of sweet potato at different durations

Moisture content of tuber and rind are important parameters which decide the quality of tubers. The initial moisture level in tubers was usually observed to be altered by storage. This difference in moisture content of the sweet potato tubers due to storage under different treatments for varying durations was studied and the results obtained as computed on percentage basis is given in Table 12.

The various storage treatments and storage durations imparted a significant influence on the moisture

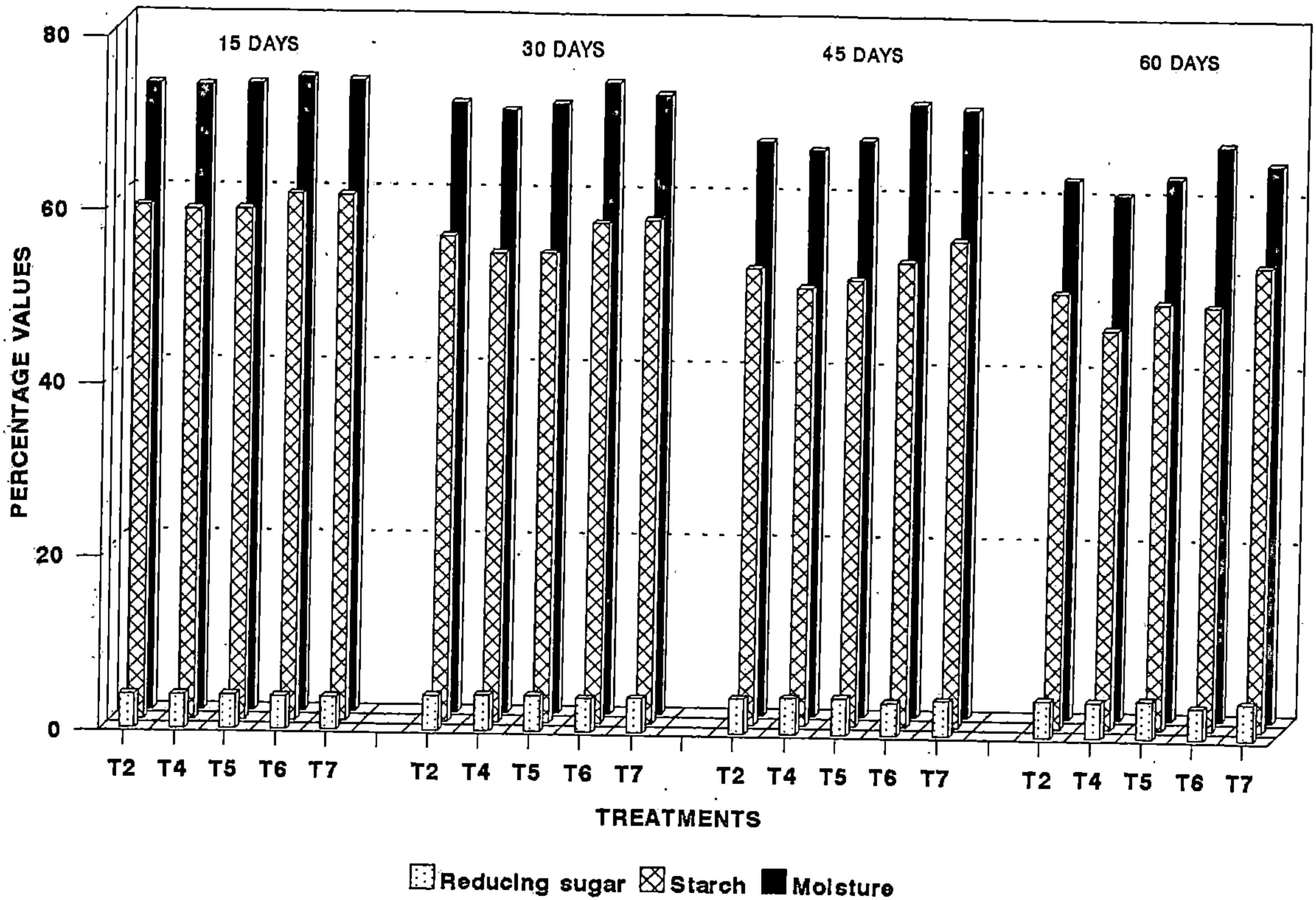


Fig. 2. Effect of storage treatments and durations on nutritional composition of sweet potato tuber

Table 12. Influence of storage treatments and durations on moisture content of sweet potato (per cent)

Storage treatments	15		30		45		60		Treatment mean of moisture content
	Moisture content(%)	% decrease from fresh	Moisture content(%)	% decrease from fresh	Moisture content(%)	% decrease from fresh	Moisture content(%)	% decrease from fresh	
T_2	72.20	2.56	70.30	5.10	66.20	10.60	62.10	16.19	67.700
T_4	72.10	4.04	69.40	6.30	65.20	11.60	60.40	18.48	66.600
T_5	72.32	2.40	70.30	5.10	66.40	10.39	62.40	15.78	67.855
T_6	73.12	1.32	72.80	1.75	70.60	4.72	66.20	10.66	70.680
T_7	72.80	1.75	71.40	3.60	70.05	5.46	64.00	13.63	69.563
Duration mean of moisture content	72.308		70.840		67.750		63.020		

F test: Me.= 122.127.** Pe.= 976.199.** Me.x Pe.= 8.575.**

CD : Me.= 0.432. Pe.= 0.386. Me.x Pe.= 0.864.

T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.

T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Moisture content present in freshly harvested tuber = 74.1% .

content of sweet potato tubers (Table 12). T_6 registered the highest moisture content of 70.68; whereas T_4 recorded significantly the lowest value (66.6).

Moisture content showed significant reduction by increasing the storage period, the lowest value was registerd by T_4 at 60^{th} day.

The table revealed that the stored samples generally gave slightly lower value for moisture content than fresh tubers. The moisture content in sweet potato is expected to be in the range of 50 to 81 per cent of fresh tuber (Onwueme., 1978). On the initial observation, the moisture content ranged from 73.12 per cent to 71.1 per cent as against 74.1 per cent, being the value obtained for the tuber freshly harvested from the field. The tubers stored in polythene covers (T_6) could retain the highest moisture content (73.12 per cent) and was in a desending scale in T_7 (waste carbon paper - 72.8 per cent), T_5 (coir pith -72.32 per cent) and T_2 (saw dust - 72.2 per cent). The lowest amount of moisture was recorded in T_4 (paddy husk) on the 15^{th} day of storage (71.1 per cent). T_2 was found to be on par with T_4; and T_6 was on par with T_7; while T_5 showed significant difference from all the treatments.

When the samples were observed on the 30th day, a uniform and gradual decreasing value was obtained for moisture content. The percentage decrease ranged from 1.7 per cent to 6.3 per cent. Lowest decrease was seen in T_6 and the highest decrease was noted in T_4.

This same trend was further observed on the 45th and 60th days of storage in all the five treatments. The moisture content on the 45th day ranged from 70.05 per cent to 65.2 per cent and the moisture range varied from 64 to 66.2 on the 60th day. T_2 and T_5 were on par during the entire period and showed a similar value in moisture content on the 30th day (70.3 per cent). The percentage decrease of moisture ranged from 4.7 to 11.6 on the 45th day; and from 10.6 to 18.4 on the 60th day of storage.

The decreasing trend in moisture percentage continued upto 60 days of storage. However, the percentage decrease was slow and not very discouraging.

In tune with the results of storage studies conducted by other workers, the tubers were subjected to moisture loss to a certain extent, by storage. Bouwkamp (1985) also reported that moisture loss is a common observation in storage of tubers, whatever be the method used for storage. Nevertheless, the moisture level of few samples were comparable with freshly harvested tuber. In the present study, the rate of moisture loss was significantly influenced by storage treatments and storage duration. These results confirmed the views of Prema and Chellammal (1986) who reported that, the pattern of moisture loss during storage is influenced by the storage materials and the duration of storage.

Kawabata _et al_. (1984) noticed 5.05 per cent decrease in moisture content of sweet potato upto 17 days storage. The present investigation recorded a moisture loss ranged from 1.75 to 6.3 per cent on the 15th day of storage in different treatments.

It was a worthwhile observation that moisture loss in T_6 (polythene covered) and T_7 (waste carbon paper) were not much noticeable upto 45 days and was less affected even upto 60 days. Treatments 6 and 7 were found less affected to moisture loss over a period of 45 days, since the percentage reduction at this time was only 4.7 and 5 respectively. Ghosh et al. (1988) had suggested the method of polythene covering for storage of tuber, based on the ability of this material in preventing moisture loss from tubers. Though, the results ofthe present study could not find the polythene covering much effective in the aspect of shelf life for the entire period of observation, this method proved to be highly advantageous in preserving moisture content at the highest level. The higher humidity level inside the polythene covers might have functioned as the preventive factor towards moisture loss. The treatment 7 (waste carbon paper) along with other qualities, presented a superior result in moisture preservation also. Lack of proper environment for the tubers to continuous respiration, as it was covered inside the carbon paper layers; along with its ability to hinder moisture depletion could be assumed as the contributing factors to this result.

Among the various treatments, T_5 (coir pith) and T_2 (saw dust) were accounted to the next place in level of moisture per cent in the stored tubers. The initial and subsequent decrease were similar in tubers of these two treatments proving that coir pith and saw dust has equal effect in checking moisture loss from tubers while storage. Roshni (1993) observed that coir pith had a special property of conserving moisture content inside it for longer time. This quality of the medium might helped the stored tubers to retain more amount of moisture. The percentage decrease varied from 2.4 to 15.7 in T_5 and 2.5 to 16.2 in T_2 from 15th to 60th days of storage. In comparison, the percentage decrease in moisture was highest in T_4 (paddy husk). Continuous respiration of tubers lead to moisture loss at greater extent (Bouwkamp, 1985). This indicate that paddy husk provided an environment for greater respiration of tubers leading to comparatively more moisture loss. The range of decrease in moisture in the treatment that recorded the lowest level (T_4) being 4.04 per cent to 18.48 per cent. However, all the treatments gave satisfactory performance in moisture level of tubers for a 60 day storage period.

4.4.2 Influence of storage treatments on the starch content of sweet potato at different storage durations

One of the major factors which govern the nutritional importance of sweet potato is its high calorific value derived from the starch content. During storage, a part of starch can be converted to other compounds or a part of starch lost through metabolism. These changes in the major constituent of sweet potato due to storage in different media at particular durations were also determined. Relevant data are persented in Table 13.

Table 13. Influence of storage treatments and durations on the starch content of sweet potato (per cent)

Storage treatments	STORAGE DAYS 15		30		45		60		Treatment mean of starch content
	starch conte-nt(%)	% dec-rease from fresh	starch conte-nt(%)	% dec-rease from fresh	starch conte-nt(%)	% dec-rease from fresh	starch conte-nt(%)	% dec-rease from fresh	
T_2	59.21	5.26	55.95	10.48	52.63	15.79	50.11	19.82	54.475
T_4	58.84	5.85	54.04	13.53	50.38	17.82	45.95	26.48	52.303
T_5	58.94	5.69	54.09	13.45	51.36	17.83	49.05	21.52	53.360
T_6	60.71	2.70	57.63	7.79	53.50	14.40	48.75	22.00	55.148
T_7	60.64	2.97	58.06	7.10	55.97	10.44	53.33	14.67	57.000
Duration mean of starch(%)	59.668		55.954		52.768		49.438		

F test: Me.= 114.068.** Pe.= 853.902.** Me.x Pe.= 10.0871.**
CD: Me.= 0.492. Pe.= 0.440. Me.x Pe.= 0.989.

T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Starch present in freshly harvested tuber = 62.5%

On persual of the data presented in Table 13, it was evident that the starch content of sweet potato tubers was significantly influenced by the storage media and duration of storage. Among the media, T_7 registered significantly highest starch content (57 per cent) and the lowest was by T_4 (52.30 per cent). Increasing the storage period significantly reduced the starch content and T_4 at 60^{th} day recorded the lowest starch content (45.95 per cent).

When the samples were stored for a period of 15 days, the starch reduction was found lowest in T_6 (polythene covered) recording 60.71 per cent, followed by T_7 (waste carbon paper) (60.64 per cent). There was only a reduction of 2.7 per cent in T_6 (polythene covered) and 2.97 per cent in T_7 (waste carbon paper) at this time; while starch content of the tuber before storage recorded was 62.50 per cent. When comparing other treatments, retention of starch was higher in T_2 (saw dust) having 59.21 per cent, followed by 58.84 per cent in T_5 (coir pith). The T_4 (paddy husk) retained 58.84 per cent, recording the lowest value. T_6 (polythene covered) was on par with T_7 (waste carbon paper); at the same time, T_4

(paddy husk), T_5 (coir pith) and T_2 (saw dust) remained on par with each other.

Starch values on the 30th day indicated an interchange in the first and second higher levels observed earlier. During this day, highest retention was recorded in T_7 (58.06 per cent), followed by T_6 (57.63 per cent). The remaining three treatments performed the same trend as on the 15th day in the decreasing order starting from T_2 (55.95 per cent), T_5 (54.09 per cent) and T_4 (54.04 per cent). T_7 (waste carbon paper) and T_6 (polythene covered) were on par and also T_5 (coir pith) was on par with T_4 (paddy husk); whereas T_2 (saw dust) recorded the middle value and was statistically different from other treatments.

All the treatments showed significant difference in their starch content on the 45th day of storage. The rate of variation followed the same trend as on the 30th day; recording a range from 55.97 per cent to 50.38 per cent. The range in percentage decrease being 10.44 to 17.82.

The final observation of starch content on the

60^{th} day of storage indicated best result in T_7 (53 per cent), where the percentage decrease was only 14.67 followed by T_2 (50 per cent) and T_5 (49 per cent). Tubers kept in polythene covers (T_6) which recorded the highest per cent of starch on the initial observation; subjected to significant loss of starch and obtained 48 per cent on the 60^h day. The lowest starch content was recorded by T_4 (45 per cent) which was on par with T_6 during this period.

The starch content in sweet potato varies from 50 to 75 per cent on dry weight basis in different cultivars (Lila, 1988). The freshly harvested tuber in the present study contains 62.5 per cent starch on the tuber dry weight. A significant difference was observed in the starch content of different treatments after storage. According to Balagopal and Moorthy (1984), a considerable reduction in starch content was occured, when sweet potato was stored for longer durations. Maini and Balagopal (1978) observed 15 to 20 per cent reduction in starch, when cassava tubers were stored in moist sand / soil upto a period of two months. In the present study, starch content in sweet potato noticed a decrease from 14 to 26 per cent by two months storage in different treatments.

Initially, the starch was found highly retained in T_6 (polythene covered), immediately followed by T_7 (waste carbon paper); which may probably be due to the lower rate of metabolism in these treatments. It was observed that T_4 (paddy husk) recorded the least per cent of starch throughout the study. This indicated that the metabolic changes were more when tubers are stored in paddy husk (T_4) compared to other treatments. Coir pith (T_5) and saw dust (T_2) could maintain more amount of starch than T_4. T_2 (saw dust) was found more efficient to prevent starch loss than T_5.

Highest fluctuation of starch during storage was noticed in T_6 (polythene covered). The starch content of T_6 (polythene covered) was seen diminished considerably from 30 day onwards. Polythene covered tubers (T_6) which recorded highest per cent of starch on 15^{th} day, came down to second higher value on 30^{th} day and by the end of the study period, it recorded the lowest per cent of starch next to T_4. The steep fall in starch content in T_6 (polythene covered) corresponds to the emergence of sprout. Higher incidence of sprouting together with weevil attack accounted for the considerable loss of starch, as the storage period was prolonged. The observation lends support to the finding of Lila and Nambisan (1991). According to these workers, starch showed a greater decrease on increased sprouting. Adesuyi (1973) also reported similar findings, stating that sprouting translocates the carbohydrate from tuber to the sprouts. Sprouting and weevil infestation of treatments - 5 (coir pith) and 2 (saw dust); eventhough was on a lesser level, probably had led to cause a rapid rate of decrease of starch content during the second month of storage. Weevil fed tubers were found with a significant decrease in starch, when compared to non-fed tubers (Rajamma, 1984).

It was proved that for storage upto 60 days, waste carbon paper (T_7) was ascertained as the best treatment, followed by saw dust (T_2) and T_5 (coir pith) which also remained preferable to limit the loss of starch in sweet potato, for prolonged durations of storage.

4.4.3 Influence of storage treatments on reducing sugar of sweet potato

Sugar content in sweet potato is considered as an important character used in describing tuber eating quality and acts as the major criterion for judging the quality. Widely varying levels of reducing sugar is measured in sweet potato depending upon variety, maturity, storage and many other factors. Variation of reducing sugar in stored tuber from its value of the unstored status is an index of change in quality of tuber. The fluctuation in the reducing sugar value of sweet potato as affected by different treatments at four regular intervals are presented in Table 14.

Table 14. Influence of storage treatments and durations on reducing sugar content of sweet potato (per cent)

Storage treatments	STORAGE DAYS 15		30		45		60		Treatment mean of reducing sugar content
	Reducing sugar (%)	% increase from fresh	Reducing sugar (%)	% increase from fresh	Reducing sugar (%)	% increase from fresh	Reducing sugar (%)	% increase from fresh	
T_2	3.90	5.40	4.06	9.72	4.10	10.81	4.24	14.49	4.075
T_4	3.94	6.48	4.18	12.97	4.21	13.78	4.16	12.43	4.123
T_5	3.91	5.67	4.15	12.16	4.29	15.94	4.37	18.10	4.180
T_6	3.81	2.97	3.89	5.13	3.78	2.16	3.64	-1.62	3.780
T_7	3.83	3.51	3.98	7.56.	4.08	10.27	4.20	13.51	4.023
Duration mean of reducing sugar	3.878		4.052		4.092		4.122		

F test: Me.= 74.199.** Pe.= 46.311.** Me.x Pe.= 9.972.**
CD: Me.= 0.053. Pe.= 0.047. Me.x Pe.= 0.106.

T_2 = saw dust. T_4 = paddy husk. T_5 = coir pith.
T_6 = polythene covered. T_7 = waste carbon paper.

Note: ** = Significant at 1% level. Reducing sugar content of fresh tuber (before storage) = 3.70% .

The reducing sugar values presented (Table 14) showed significant variation due to storage media and duration. T_5 recorded 4.18 per cent reducing sugar content which is significantly superior to others and closely followed by T_4 (4.12). T_6 represented the lowest content of 3.78.

Increasing the storage period increased the reducing sugar content upto 45 days; and on 60th day, the mean value was lowered to 4.122 per cent.

Among the different combinations, storage in T_2, T_4 and T_5 on 15th day recorded the lowest reducing sugar while storage on T_5 on 60th day recorded the highest reducing sugar content (4.37).

The initial observation on the 15th day of storage revealed that there was the highest per cent of reducing sugar in T_4 (paddy husk), followed by T_5 (3.91) and T_2 (3.90). The tubers in waste carbon paper (T_7) recorded a per cent of 3.83, followed by T_6 (3.81). T_7 was on par with T_6, while all other treatments differ significantly.

Storage of sweet potato for 30 days followed a steady rise and the same trend in rate of increase of reducing sugar in all the five samples, similar to that of in the 15th day. The range of values recorded from the highest to lowest level where 4.18 (T_4) to 3.89 (T_6).

Observation of samples on the 45th day of storage indicated a wavering difference from that observed upto the 30th day. The reducing sugar content in T_6 (polythene covered) showed a sudden decreasing trend, whereas increasing tendency was observed in the other four treatments. The tubers stored in coir pith (T_5) recorded the highest value of reducing sugar when increased to 4.29 per cent, followed by T_4 (4.21), T_2 (4.10) and T_7 (4.08). T_6 (polythene covered) obtained the lowest value (3.78), distinguished by showing a reduction in the amount of reducing sugar existed on this day. T_2 was on par with T_5; while other treatments showed significant difference statistically.

When the stored samples were observed on 60th day of storage, T_4 (paddy husk) that performed the highest value also viewed a decreasing level along with T_6 (polythene covered) in which this tendency was noticed on

45^{th} day itself. Whereas T_2 (saw dust), T_5 (coir pith) and T_7 (waste carbon paper) continued to maintain the increasing trend. The highest per cent was noticed in T_5 (4.37), followed by T_2 (4.24) and T_7 (4.20). The per cent of reducing sugar recorded in T_4 was 4.16, followed by T_6 (3.64 per cent); which had the lowest value on this period. T_5 (coir pith) was found on par with T_7 (waste carbon paper); while T_7 was on par with T_2 (saw dust); and the treatments 4 (paddy husk) and 6 differ significantly with all treatments.

The reducing sugar in sweet potato constitute 0.85 to 6 per cent of tuber dry weight in different cultivars (Lila, 1988). The value obtained for the variety selected for this study is 3.7 per cent before storage. Findings of the present study in general showed an increasing trend in reducing sugar content after storage and linearly increased in most cases by time of storage. The reducing sugar content in fresh tuber increased from 12.43 to 18.10 per cent after storage period of 60 days in different treatments. An increase in reducing sugar was reported by Balagopal and Moorthy (1984) and Bouwkamp (1985). Increase in reducing sugar content occurs when the starch gets converted to sugars (Ghosh et al., 1988). From the results, it is clear that T_4 recorded the highest reducing sugar value upto 30 days of storage. It was noted that the starch conversion in T_4 (paddy husk) was also rapid in this treatment. The rate of increase was found limited in the other treatments during the first month of storage.

Present observation indicate that apart from starch conversion, some other factors also contribute to the change in reducing sugars. The diminishing trend of reducing sugar in T_6 (polythene covered) from 45^{th} day followed by T_4 (paddy husk) on the 60^{th} day adds to this assumption. At the termination of the study, the reducing sugar content in T_6 was 1.62 per cent less than the value observed before storage. This was reflected in the taste also. Such loss in sugar was probably due to sprouting of tubers under these treatments. Lila and Nambisan (1991) also correlated the sprouting incidence with rate of decrease of sugars. Weevil attack is another factor which lessen the sugar content. The increase in sugar content was also reported to attract insects and micro organisms, thereby decreasing the sugar content by their feeding (Balagopal and Moorthy, 1984). This finding is in agreement with the findings of present study. Thus, the decreasing trend of reducing sugar in T_4 (paddy husk) during the end of second month may be explained by the attraction of insects and micro organisms to this particular treatment, and considerable sprout growth.

The reducing sugar content of sweet potato observed an increase of 10 per cent by two months of storage (Ghosh et al., 1988). In the present investigation, there was an increase from 13 to 18 per cent of reducing sugar on the 60th day of storage in different treatments.

The treatments - 2 (saw dust), 5 (coir pith) and 7 (waste carbon paper) maintained a regular increase of reducing sugar during the entire period of study. The rate of increase was found higher in T_2 and T_7 when compared to T_5 upto 60 days. Meagre rate of sprout growth and weevil attack may be the reason for this observation in T_2 (saw dust).

Considering all the treatments studied, T_6 (polythene covered) obtained lowest reducing sugar per cent throughout the study. Starch loss was comparatively higher in this treatment due to emergence of sprout and weevil attack. Due to this same reason, reducing sugar was also lowered as against increase through converted starch. The lower level of both starch and reducing sugar at the same time in T_4 (paddy husk) could also be justified by the above deteriorative change. Waste carbon paper (T_7) and saw dust (T_2) that were found less prone to starch conversion as sugars maintained the moderate level in converted sugar per cent also. The highest percentage increase in reducing sugar was noticed in T_5 (coir pith) on the 60^{th} day of storage, at a level of 18 per cent.

SUMMARY

SUMMARY

The shelf life and storage behaviour of sweet potato using different locally available materials with reference to changes in nutritional, organoleptic and cooking characteristics were ascertained. The storage media selected were, ordinary basket (T_1), saw dust (T_2), mud coating (T_3), paddy husk (T_4), coirpith (T_5), polythene covers (T_6), waste carbon paper (T_7) and open storage as control (T_0). Observations were taken for a period of 60 days at each 15 day intervals. Important findings of the study are summarized below:

The extent of weevil damage, weight loss, symptoms of rotting, sprouting and other physical changes in the stored tubers were analysed to assess the shelf life of tubers. Openly stored and mud coated tubers exhibited higher incidence of weevil beyond 15th day of storage; while in tubers stored in ordinary basket and polythene covers, an enhancement in pest attack was observed after 45 days of storage. It could be highlighted that among all the treatments imposed, waste

carbon paper proved to be best, followed by sawdust to resist weevil attack upto 60 days of storage. Coirpith and paddy husk were satisfactory in minimizing weevil damage for 45 days.

The rate of loss in weight was always higher with tubers stored in open, followed by tubers in ordinary basket and mud coated. However, higher dehydration and early spoilage were major. At all durations, polythene covered tubers recorded maximum weight and maintained 76 per cent of fresh weight on 60th day. Tubers stored in waste carbon paper, coir pith, sawdust and paddy husk recorded 74, 72, 69 and 68 per cent weight respectively, on this day.

Openly stored and mud coated tubers claimed symptoms of rot on the 30th day of storage, and in tubers in ordinary baskets, the same was observed on the 60th day of storage. The five treatments - saw dust, paddy husk, coir pith, polythene covers and waste carbon paper were free from rotting symptoms for the entire period of study.

Tubers in ordinary baskets, open stored and mud coated exhibited no sprouting which was due to dehydration and decay. By 30th day of storage, sprout was seen on polythene covered tubers (T_6) at a low level and the same was significantly increased on the 45th day. At this time, paddy husk and saw dust were noted with less sprout growth, that enhanced slightly at the 60th day of storage. The tubers stored in coir pith was free from sprouting upto 45 days, exhibited minimum sprout on the last observation. Among the treatments studied, T_7 (waste carbon paper) was found to be free from sprout growth till 60 days.

The other physical changes associated with deterioration, like shrivelling, softness and dullness were higher with T_0 (control), T_1 (ordinary basket) and T_3 (mud coated) after 30th day of storage, while treatments 2 (sawdust), 4 (paddy husk), 5 (coir pith), 6 (polythene covered) and 7 (waste carbon paper) were not subjected to the above changes upto 60 days.

T_0 (control), T_1 (ordinary basket) and T_3 (mud coated) that were not survived upto the termination of study were excluded from analysis of further qualitative changes.

The cooking characteristics studied were optimum cooking time and apparent water absorption. The time taken for cooking increased with increased duration of storage; while the trend was reversed in the case of water absorption. The least deviation from the freshly harvested tuber in cooking time and water uptake was noticed in T_6 (polythene covered), followed by treatments 7 (waste carbon paper), 5 (coir pith) and 2 (sawdust); whereas T_4 (paddy husk) recorded comparatively higher difference.

Various organoleptic qualities (appearance, colour, taste, flavour, texture and doneness) and overall acceptability of cooked tubers were judged. In general, various organoleptic scores of all the five storage methods remained unchanged till 30th day, and of storage. Overall acceptability was enhanced in T_6 (polythene covered) on the 30th day. Over this period, all treatments indicated a reduction in overall acceptability of varying degrees. However, treatments 7 (waste carbon paper) and 2 (saw dust) possessed greater acceptability upto 60 days, while T_4 (paddy husk) and T_5 (coir pith) were less acceptable and at the same time, T_6 (polythene covered) was found not at all acceptable.

The change in nutritional composition of stored tubers were ascertained by estimating moisture, starch and reducing sugar. Moisture and starch contents decreased with increase in duration of storage, while reducing sugar showed an increasing trend generally. The decrease in moisture content of T_6 (polythene covered) and T_7 (waste carbon paper) were lesser while it was moderately high with T_5 (coir pith) and T_2 (saw dust) on all the durations. T_4 (paddy husk) recorded a comparatively higher loss in moisture.

Starch was always considerably retained in T_7

(waste carbon paper) followed by T_2 (saw dust). T_6 (polythene covered) retained the highest amount of starch initially, but later there was greater reducton from 45th day onwards. A regular increase in reducing sugar was observed in all the five treatments till 30th day. But in T_6 (polythene covered), the same was decreased on 45th day, and the same trend was noticed in T_4 (paddy husk) during 60th day. Reducing sugar was more steady in T_2 (saw dust), T_7 (waste carbon paper) and T_5 (coir pith) over 60 days of storage.

The various observations for 60 days regarding shelf life, changes in cooking and organoleptic qualities, overall acceptability and nutritional composition of sweet potato stored under different methods were in favour of waste carbon paper as the best storage treatment, followed by saw dust and coir pith; since these treatments recorded only minimum change due to storage in the various aspects studied. Satisfactory results were observed with paddy husk when used as the storage media. Even though, the tubers stored in polythene covers exhibited best result in most of the qualities at the initial month of observation, greater weevil incidence and sprouting caused damage and reduced its overall acceptability and nutritional qualities, thus limiting the storage feasibiliity of the treatment beyond 45 days. However, the experiments based on these media for prolonging shelf life of sweet potato has to be scrutinized with different moisture levels of media and climatic conditions before drawing definite conclusions.

Further addition to the highly protective effect distinguished by waste carbon paper in the study is recommended to develop this material to a more feasible storage media by bringing in suitable improvisations. Covering tubers with waste carbon paper in large scale storage has its limitations as it is time consuming and difficult to collect the used up carbon sheets when required in bulk. Methods to duplicate the carbon coated effect at less cost has to be devised and tested for confirmation of results which has practical utility for large scale storage. Attempts to exploit the potentialities of polythene cover as a better storage material can also be made by imposing proper treatments to check sprouting and weevil entry.

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* Originals not seen.

APPENDICES

APPENDIX-1

Evaluation card for triangle test

Name of the product: sugar solution

Note: Two of the three samples are identical.
Identify the odd sample

Serial no.	Code no. of sample	Code no. of ide.samples	Code no of odd sample
1.	A B C		
2.	X Y Z		

Name of the judge:

Signature:

APPENDIX-2

Score card for the organoleptic evaluation of cooked sweet potato

Name of the judge: Date:
Signature:

Quality attributes:	Sub divisions of each attributes:	Score for each sub-divided attributes	Score for different samples:code no. of each samples 1	2	3	4	5	6	7	8
Appearance	Very Good	4								
	Good	3								
	Fair	2								
	Poor	1								
	Very poor	0								
Colour	Yellow	4								
	Pale yellow	3								
	Green	2								
	Brownish yellow	1								
	Brown	0								
Taste	Much sweet	4								
	Sweet	3								
	Less sweet	2								
	Bland taste	1								
	Bitter	0								
Flavour	Excellent	4								
	Pleasant	3								
	Neither Pleasant nor Unpleasant	2								
	Unpleasant	1								
	Very unpleasant	0								
Texture	Very soft	4								
	Slightly fibrous	3								
	Soft & sticky	2								
	Very sticky	1								
	Woody	0								
Doneness	Well cooked	4								
	Cooked	3								
	Moderately cooked	2								
	Poorly cooked	1								
	Uncooked	0								

APPENDIX -3

Ranking for overall acceptability score of sweet potato stored under different methods

Criteria	Rank	% of score for each rank	Range of score in each rank	Score for various samples: sample code no. 1	2	3	4	5
Very good	4	80 and above	19 and above					
Good	3	70 to 79	16.6 to 18.9					
Satisfactory	2	60 to 69	14.3 to 16.5					
Unsatisfactory	1	40 to 59	9.5 and below					
Poor	0	39 and below	9.4 and below					

<u>Date of scoring:</u>

APPENDIX - 4

Effect of storage treatments on weevil incidence, cooking characters and nutritional composition of sweet potato

Abstract of ANOVA

[Mean Squares]

S.V.	Weevil incidence		D.F.	Cooking Characters		Nutritional Composition		
	D.F.	Damage grade index		Optimum cooking time(min)	Apparent water up take(%)	Moisture (%)	Starch (%)	Reducing sugar(%)
Media (Me.)	7	** 0.941	4	** 22.350	** 9.560	** 21.086	** 25.576	** 0.191
Period (Pe.)	3	** 2.845	3	** 154.900	** 76.664	** 168.547	** 191.461	** 0.119
Me.x Pe.	21	** 0.193	12	NS 0.983	** 0.584	** 1.480	** 2.262	** 0.026
Error	24	0.057	20	0.700	0.003	0.173	0.224	0.003

Note: ** = Significant at 1% level. NS = Not significant.

APPENDIX - 5

Effect of storage treatments on organoleptic qualities and overall acceptability of sweet potato

Abstract of ANOVA

S.V	D.F.	M.S Appearance	Colour	Taste	Flavour	Texture	Doneness	Over all acceptability
Media (Me.)	4	15.835**	6.840**	11.210**	7.371**	3.610 NS	6.102**	266.984**
Period (Pe.)	3	44.822**	72.143**	19.450**	147.773**	61.560 NS	28.143**	1828.971**
Me.x Pe.	12	8.052**	7.063**	13.220**	3.938**	1.277 NS	3.376**	159.013**
Error	20	0.002	0.002	0.002	0.005	0	0.002	0.015

Note: ** = Significant at 1% level. NS = Not significant.

APPENDIX - 6

Data on cooking characteristics, nutritional composition and over all acceptability of treatments excluded from discussion

Storage treatments	Cooking characteristics: Optimum cooking time (minutes)			Cooking characteristics: Apparent water uptake (%)			Nutritional Composition: Moisture (%)			Nutritional Composition: Starch (%)			Nutritional Composition: Reducing sugar (%)			Overall acceptability (mean score)		
	Storage days			Storage days			Storage days			Storage days			Storage days			Storage days		
	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45
Ordinary basket (T_1)	28	31	38	47.90	45.8	40.75	71.04	68.00	60.64	58.25	53.28	49.81	3.96	4.21	4.30	23	21.20	17.80
Mud coated (T_3)	30	34	38	46.22	43.7	40.65	68.50	64.80	60.30	58.01	53.66	48.91	3.93	4.18	4.05	21	15.95	4.95
Control (T_0)	36	39	--	42.15	37.9	--	62.50	56.20	--	57.87	51.42	--	4.03	2.39	--	23	6.65	--

APPENDIX - 7

Data on organoleptic qualities of treatments excluded from discussion

Storage treat-ments	QUALITY ATTRIBUTES																	
	Appearance			Colour			Taste			Flavour			Texture			Doneness		
	Storage days			Storage days			Storage days			Storage days			Storage days			Storage days		
	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45
Ordinary basket (T_1)	4	3.00	2.70	4	4	4	3	4.00	4	4	3.0	2.0	4	3.20	2.3	4	4.00	2.7
Mud coated (T_3)	3	2.05	0.65	4	1.95	0.75	3	3.00	0	3	2.0	0.6	4	2.95	1.0	4	4.00	2.0
Control (T_0)	3	0.75	--	4	0.85	--	4	1.05	--	4	1.3	--	4	1.65	--	4	1.05	--

ABSTRACT

CHANGES IN COOKING QUALITIES, NUTRITIONAL COMPOSITION AND SHELF LIFE OF SWEET POTATO STORED UNDER DIFFERENT METHODS

By

Seema Thampi. S.

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
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ABSTRACT

The investigation on "Changes in cooking qualities, nutritional composition and shelf life of sweet potato stored under different methods" was carried out to find out the keeping quality of sweet potato tuber with reference to extent of damage, changes in cooking, organoleptic and nutritional qualities of the tuber as influenced by different low cost storage treatments at various durations of storage. The results obtained are depicted below:

Incidence of pest and diseases were comparatively absent upto 15th day of storage, beyond which, such incidence were observed in some of the treatments. Tubers stored in waste carbon paper was free from pest and disease during the entire period of storage, followed by saw dust which showed an initial stage of external weevil damage on the 60th day. All the treatments except control, mud coated and ordinary baskets were free from symptoms of rotting upto 60 days. Weight loss, shrivelling and drying of tubers were more pronounced as the duration of storage was extended. Methods using waste carbon paper, polythene covers, saw

dust and coir pith proved to minimize such losses in storage.

Tubers stored in waste carbon paper exhibited no sprouting till the 60th day of storage. Samples in saw dust and coir pith recorded less than 25 per cent sprouting on 60th day of storage; while polythene covered sample showed higher incidence of sprout from 45 day onwards of storage.

Cooking time of tubers increased with increase in durartion of storage, while quantity of water absorbed by the tubers decreased. The samples kept in waste carbon paper and polythene covered showed best results in cooking characteristics, followed by coir pith, saw dust and paddy husk. Organoleptic qualities remained unaffected during the initial month of storage. Storage media like waste carbon paper and saw dust performed better results in terms of appearance, colour, taste, flavour, texture and doneness; whereas complete loss of taste and flavour was observed in polythene covered samples by the end of storage study, eventhough superior results were given at the beginning. In general, taste increased with short term storage upto 45 days and decreased with prolonged storage. Tubers kept in waste carbon paper and saw dust observed higher overall acceptability, followed by coir pith and paddy husk.

Moisture and starch content decreased with increased time of storage, while reducing sugar increased. Moisture content in samples stored in waste carbon paper and polythene covers was higher, followed by saw dust and coir pith. Starch content was always more with tubers covered in waste carbon paper and saw dust; and comparatively lesser with paddy husk; while reducing sugar content was least in polythene covered and paddy husk; where higher sprouting was noticed; while more concentration of reducing sugar was found in storage treatments using saw dust, waste carbon paper and coir pith.

In conclusion, among the eight storage methods evaluated for the performance, the results were in favour of using waste carbon paper as best storage medium, followed by saw dust and coir pith from nutritional, acceptability and shelf life point of view.