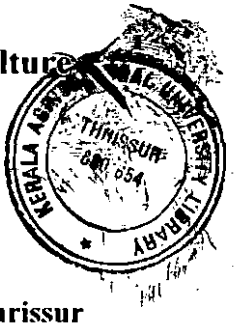
PRODUCT DEVELOPMENT IN DRUMSTICK

(*Moringa oleifera* Lam.)

MINONTI PAIT

Thesis submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture



Faculty of Agriculture
Kerala Agricultural University, Thrissur

2006

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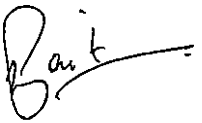
DECLARATION

I hereby declare that this thesis entitled **"Product development in drumstick (*Moringa oleifera* Lam.)"** 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, fellowship or other similar title, of any other university or society.



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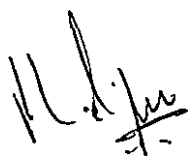
CERTIFICATE

Certified that this thesis entitled **"Product development in drumstick (*Moringa oleifera* Lam.)"** is a record of research work done independently by Ms. Minonti Pait (2004-12-05) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.



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Minonti Pait
(2004-12-05)

Dedicated to

My Beloved Parents

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LIST OF ABBREVIATIONS

%	–	Per cent
°C	–	Degree Celsius
CD	–	Critical difference
CHO	–	Carbohydrate
cm	–	Centimeter
CO_2	–	Carbon dioxide
CRD	–	Completely Randomized Design
et al.	–	And others
FIB	–	Farm Information Bureau
Fig.	–	Figure
FPO	–	Food Product Order
g	–	Gram
i.e.	–	That is
IU	–	International Unit
KAU	–	Kerala Agricultural University
mg	–	Milligram
N	–	Nitrogen
PET	–	Polyethylene terephthalate
viz.	–	Namely

Introduction

1. INTRODUCTION

Drumstick (*Moringa oleifera* Lam.) is a vitamin rich, mineral packed perennial vegetable belonging to the family Moringaceae. It is also known by other names as 'Horse Radish Tree', 'West Indian Ben', and 'Never Die'. It's a native of North-West India and is widely distributed in India, Sri Lanka, Pakistan, Singapore, Malaysia, Cuba, Jamaica and Egypt (Ochse, 1977; Ramachandran *et al.*, 1980).

The variety of products that can be obtained and the number of uses for which drumstick can be put to, have pushed this plant to the fore-front of rural development. The leaves, fruits and flowers are used as nutritious vegetable. They are rich sources of proteins, amino acids, vitamins and minerals (Rajkumar *et al.*, 1973). Roots are good substitute for horse radish. Seeds yield 'ben oil' which is much valued in perfumery and pharmaceuticals (Delaveav, 1980). The press cake remaining after oil extraction is used as manure (Prabhakar *et al.*, 2003). Seeds are also used for water purification (Manickam and Ghosh, 1986). The bark fibre is used for making mats, paper and cordage (Seemanthini, 1964; Arkroyd, 1966; Verma *et al.*, 1976; Ochse, 1977; Peter, 1978 and 1979).

Fruits have been used against diabetes and some compounds from the roots act to reduce the fertility in mice (Mossa, 1985; Shukla *et al.*, 1988). Considering these remarkable attributes the crop has been identified as important both in dry land agriculture as well as in agri-horti-silvi programme (Sundaraj *et al.*, 1970; Morton, 1991).

In Kerala, the humid tropics of India, drumstick is grown in most of the homesteads and the total area is estimated as 19,632 ha with a production of 20,825 t (F.I.B., 2003).

Despite its nutritional, economic and medicinal importance, the crop still remains neglected and not much work has been done on its improvement or processing.

According to Indira and Peter (1988) in South India, there were two fruiting peaks, one in March-April and second in July-September, only one flowering season during February-March was recorded both in Lucknow and Punjab (Singh, 1962; Nair and Singh, 1974). So at this peak fruiting period, when the fruits are available in plenty, can be processed into more value added products in order to make them available for consumption throughout the year in scarce area. Moreover processed products of drumstick can also be exported in order to earn valuable foreign exchange. Hence importance for processing need to be emphasized.

Thus a study which explores, not only the nutritional quality but also the possibility of developing various food products using drumstick is a necessity. Therefore there is scope for converting drumstick into several processed products like dehydrated drumstick, canned drumstick, pickled drumstick which can provide a variety to the consumer and also help in consumer acceptance ultimately leading to an increase in drumstick production. It is about time that underexploited perennial crop like drumstick with its many uses should be brought out of their present state of ignomity towards a brighter future of proper utilization and management. With this background, a study was undertaken at the Department of Processing Technology, College of Agriculture,

Vellayani, during the period 2005-2006 on "Product development in drumstick (*Moringa oleifera* Lam.)" with the following objectives:

— To develop and standardise new products

— To evaluate the quality and shelf-life of the new products

— To assess the consumer acceptance of the new products

Review of Literature

2. REVIEW OF LITERATURE

Drumstick (*Moringa oleifera* Lam.) is a vitamin rich, mineral packed nutritious vegetable of the tropics and subtropics. It is valued mainly for the tender pods. The leaves and flowers are also eaten as vegetable.

Detailed studies on product development in drumstick are scarce. Efforts have been made to collect the available literature. Relevant work on other crops have been reviewed wherever information is lacking in drumstick.

2.1 DRUMSTICK – IMPORTANCE AS VEGETABLE

Dogra *et al.* (1975) reported that the tender pod-like fruits of moringa tree are used in the preparation of various types of vegetable curries and pickles throughout India.

Almost every part of the plant is of value for food. Tender pods are cut into pieces and are used in culinary preparations (Indira and Peter, 1988). Foliage is eaten as greens, in salads, in vegetable curries, as pickles and for seasoning. Seed is said to be eaten like peanut in Malaya. Thickened root is used as substitute for horse radish.

Moringa is an excellent vegetable used for culinary purpose in most of the tropical countries like Philippines, Hawaii, Gautemala, Malaysia, Ceylon and Indonesia (Morton, 1991). Pods of drumstick when still very young and pliable, the entire pod can be cooked and eaten in the same manner as green bean. The taste of young pods has been compared to asparagus by some people (Gill, 2005).

2.2 MEDICINAL IMPORTANCE OF DRUMSTICK

According to Hartwell (1971), the flowers, leaves and roots are used in folk remedies for tumors. He further reported that the root decoction is used in Nicaragua for dropsy.

Felicia *et al.* (1993) had obtained favourable clinical plasma glucose response by administering 50 g (fresh leaf weight) of cooked drumstick leaves for five days to adults weighing 60 kg.

Dangi *et al.* (2002) revealed that drumstick leaves have traditionally been used in Ayurvedic medicine for their antihypertensive activity.

John and Chellappa (2005) revealed that the cooked leaves of drumstick were shown to decrease blood glucose levels.

Lakshmi and Radha Priya (2005) found that drumstick flowers were used in treating cold and anaemia and reported to contain powerful antibiotic pterygospermin which has fungicidal properties. Pods are used as anthelminitic and are used in affections of the liver and spleen and in treating articular pain (Dewangan *et al.*, 2006).

2.3 NUTRITIONAL SIGNIFICANCE

2.3.1 Ascorbic Acid

Dogra *et al.* (1975) reported that the pods and leaves of drumstick are rich sources of vitamin C.

Similarly, Verma *et al.* (1976) observed that the vitamin C content in tender stage of the pods of different clones of drumstick varied from 75-131 mg/100 g and in mature stage it varied from 93-143 mg/100 g.

The drumstick leaves are reported to be richer in ascorbic acid than tomato, radish, carrot and pea (Peter, 1979 and Nautiyal and Venkataraman, 1987).

Dahot (1988) detected an significant amount of ascorbic acid in seeds and flowers of drumstick. He further stated that flowers were particularly rich in ascorbic acid.

Wijayawardana *et al.* (2002) observed that vitamin C content in the fresh sample of the drumstick fruit was 118 mg/100 g edible portion.

2.3.2 Vitamin A

Peter (1979) had reported that drumstick leaves contain an equal amount of vitamin A (11,300 I.U/100 g) as carrot roots.

Similarly, Indira (1982) revealed that drumstick leaves contain highest amount of carotene among green leafy vegetables.

Dahot (1988) found a significant amount of carotene in seeds and flowers of drumstick.

Lakshmi and Radha Priya (2005) reported that the total carotenoid content of oven dried drumstick flowers had 11.11 mg per 100 g.

Gill (2005) observed that the leaf powder of drumstick can be used as a nutritional additives to soups, sauces etc. Although some of the nutritional content is lost in the drying process, the powder remain excellent source of vitamin A.

2.3.3 Fibre

Sreeramulu (1984) found that among different green leafy vegetables grown in Tanzania drumstick contained lowest quantity of fibre (5.7 g/100 g).

Similarly, Awasthi and Tandon (1988) revealed that the leaves of drumstick had low fibre content.

Indira and Peter (1988) reported that fibre content of drumstick leaves was 0.9 g/ 100 g and fruits 4.8 g/100 g fibre.

Lakshmi and Radha Priya (2005) reported that oven dried drumstick flowers had a high amount of fibre (13.6 g).

2.3.4 Protein

Peter (1979) revealed that drumstick leaves contain 6.7 g of protein equivalent to peas.

Verma *et al.* (1976) reported that the detoxified seed meals of *M. oleifera* and *M. concanensis* were found to be rich in protein having 50 per cent and 72.6 per cent respectively.

According to Sreeramulu (1984) *Cassia tora, Gynandropsis gynandra, Solanum nigrum* and *Moringa oleifera* grown in Tanzania contained highest protein followed by *Basella argentea.*

Awasthi and Tandon (1988) found that the leaves of drumstick, *Glycine max* and *Solanum nigrum* had a high protein value.

Chakraborti *et al.* (1988) opined that leaves of drumstick contained appreciable amount of crude protein.

Gupta *et al.* (1989) observed that protein content in amaranth, drumstick, fenugreek and pumpkin varied from 25.1 to 28.5 per cent.

2.3.5 Fat

The seeds obtained from the mature fruits of *M. oleifera* and *M. concanensis* after extraction with n-hexane yielded pale yellow fat at 27 per cent and 33 per cent respectively (Verma *et al.*, 1976).

Indira and Peter (1988) found that fruits of drumstick contain 0.1 g per 100 g of fat.

Rai *et al.* (2004) revealed that leaves of drumstick have 1.7 g fat.

2.3.6 Carbohydrate

Indira and Peter (1988) reported that the total carbohydrate content of drumstick leaves was 12.5 g per 100 g while that of fruits was 3.7 g per 100 g.

Lakshmi and Radha Priya (2005) analysed the fresh values of carbohydrate of drumstick flowers and plantain flowers and found that drumstick flowers contain 7.1 g per 100 g whereas plantain flowers had 5.1 g per 100 g. They further opined that carbohydrate content of the dehydrated samples were greater than that of fresh samples.

2.3.7 Minerals

Calcium, iron and zinc percentage in fresh leaves of moringa are 0.2182, 0.008939 and 0.0827 respectively as reported by Rajkumar *et al.* (1973).

Among the various green leafy vegetables drumstick leaves are reported to contain highest amount of calcium (Peter, 1979; Nautiyal *et al.*, 1987).

Rai *et al.* (2004) reported that the leaves of drumstick contain 2.3 g per 100 g minerals.

Lakshmi and Radha Priya (2005) found that the fresh drumstick flowers and plantain flowers had 51 and 32 mg per 100 g of calcium respectively. They further reported that fresh drumstick flowers have 90 mg per 100 g of phosphorus.

2.4 PRODUCT DEVELOPMENT AND PACKAGING MATERIALS

2.4.1 Dehydrated Products

According to Lal *et al.* (1998), for large scale production of dried vegetables, dehydration is the proper method.

Pruthi (2001) have carried out a systematic investigation on the dehydration of garlic with a view to prepare garlic powder which finds extensive use in the manufacture of soup powders and medicinal preparation with bacteriostatic properties. Further they stated that powder is hygroscopic and requires stringent packing.

Khader (2004) opined that foods are dehydrated to protect against spoilage by microorganism and to reduce the cost of packaging, handling, storing and transporting. It was also reported that dried vegetables are lighter in weight than their corresponding fresh produce and at the same time they do not require refrigerated storage.

According to Gill (2005), leaves of drumstick can be dried, crushed into powder and stored for use as a nutritional additive to soups, sauces etc.

Gupta (2006) opined that powdered vegetables should be packed only in air tight tin or glass container to prevent not only insect infestation but also absorption of moisture with consequent caking. Further he stated that such powders are very susceptible to oxidative changes, hence exclusion of air in a vacuum-sealed tin or jar is desirable.

2.4.2 Canned Products

Drumstick a low acid vegetable known for its high vitamin content has export potential as a canned product. It retains its wholesomeness and quality in terms of vitamin C retention after canning (Wijayawardana *et al.* 2002).

2.4.3 Packaging Materials

According to Dauthy (1995) some of the packing methods under vacuum or inert gases (CO_2 and N) are in use which is applied mainly for packing dried carrots in order to avoid beta carotene oxidation. It was further stated that sun or artificial light action on dehydrated vegetables generally causes discoloration which can be avoided by opaque packaging materials.

According to Lal *et al.* (1998) high density polythene packages and multiple aluminium foil pouches etc. are being utilized for packing dried vegetables like peas, vegetable mixes, soup mixes etc for retail distribution.

Gupta (2006) stated that cartons, cans, glass containers and pouches can be used to pack dehydrated foods. He further stated that the final package should be inexpensive attractive in appearance and as nearly insect and moisture proof as possible.

2.4 SHELF LIFE STUDIES

According to Nanda (1984) during testing and evaluation of available packing materials for handling and storage of cassava products showed that

an increase in moisture content was minimum for cassava chips stored in metal container and polyethylene lined jute bag. The moisture content was within safe limits upto 60 days.

Jellinick (1986) observed that there was loss of ascorbic acid in the processed food products under the influence of atmospheric oxygen during storage.

According to Bhattacharjee and Bhole (1989) food packaging and storage is the vital step to ensure product quality because it provides protection against deterioration and damage during storage, transportation and distribution. They studied the keeping quality of wheat in different packaging materials and recommended that it would be stored safely in polyethylene bags for a period upto 35 days, in polyethylene impregnated jute bag upto 21 days and in jute bags only upto 14 days from the stand point of free fatty acid in stored wheat floor.

Shelf life qualities are essential parameters to be assessed since it determines the suitability of a particular ingredient for product development (Livingstone *et al.*, 1993).

Varsany (1993) reported that the mechanism and kinetics of the food deterioration can be controlled by the storage technique applied.

Studies on shelf life of snack products made from bajra were conducted by Seth and Rathore (1993). The products were stored in five different types of containers *viz.*, glass, tin, plastic and polyethylene bags of 200 and 400 gugage. No significant change could be found in chemical attributes.

Oomen (1995) reported that osmotically treated dehydrated jackfruit product showed a storage stability of five months.

According to Thakur *et al.* (1995) chemical and sensory changes are influenced by storage period and containers.

Chadha (2002) reported that dehydration (below 5 %) moisture helps to preserve nutritive value of the product although heat-labile vitamin losses are more. He also stated that the dried products have more shelf life if properly packed and stored.

2.5 SENSORY QUALITY EVALUATION AND ACCEPTABILITY STUDIES

Scientific methods of sensory analysis of food are becoming increasingly important in evaluating the acceptability of the food product. When the quality of food is assessed by means of human sensory organs, the evaluation is said to be sensory analysis. Organoleptic qualities play an important role in evaluating the quality of food products.

Jellinick (1986) reported that the first impression of food is usually visual and major part of our willingness to accept a food, depends upon its colour.

Organoleptic qualities such as colour, flavour, taste, texture and appearance are assessed with a panel of selected judges (Watts *et al.*, 1989). The combination which got the highest scores was selected for formulation of products.

According to Herrington (1991) sensory evaluation technology is a method using skilled management and trained panelists to provide confirmation on the acceptability of the product in terms of product profile, consumer acceptability and consistency.

Brue *et al.* (1991) had stated that the important factors in the marketing of products are its looking, eating and processing qualities. This include the flavour, texture and appearance of the product.

According to Mc Dermott (1992) sensory method in which palatability is evaluated by a panel of judges is essential to every standardization procedure because they answer all important questions of the food tastes, smells, looks and feels.

Rajalekshmi (1993) described sensory analysis as a scientific discipline used to evoke, measure, analyse and interpret reaction to those characteristics on food materials as perceived by the sense of sight, smell, taste, touch and hearing.

Johns (1993) had stated that, for consumer the perceivable sensory attributes, colour, apperance, feel, aroma, taste and texture are the deciding factors of food acceptance.

According to Shankar (1993) several factors such as raw material quality, storage temperature, storage container, process employed and the environment in which it is processed will have an effect on the quality of the food material.

Dorko and Penfield (1993) reported that the aesthetic, safety, sensory characteristics and acceptability of foods are all affected by colour.

Wayre (1994) stated that taste is not only a sensory response to soluble materials but also aesthetic appreciation of the mouth.

Almedia and Noguira (1995) reported that organoleptic properties determine acceptance of food by the consumer with appearance being the first factor that determine the acceptance or rejection of a food.

Sharma *et al.* (1995) revealed that taste is the primary and most important quality among various attributes. They also reported that colour scores were significantly related with acceptability.

Jack *et al.* (1995) reported that texture is a sensory attribute resulting from interaction between food and its consumer. It is the physical property of food stuffs apprehended by the eye, the skin and the mouth.

Nikolaidias and Labuza (1996) opined that texture is an important sensory attribute for many cereal based foods and the loss of desired texture results in a loss of product quality and a reduction in shelf life.

Texture is the property of food which is associated with the sense of feel or touch experienced by the finger or the mouth (Ranganna, 2001).

Food judging consumer acceptability and organoleptic evaluation is essential for any food product (Sini, 2002; Liya, 2002; Bini, 2003).

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled "Product development in drumstick (*Moringa oleifera* Lam.)" was undertaken at the Department of Processing Technology, College of Agriculture, Vellayani during 2005-2006. The investigation comprised of different drumstick products prepared from drumstick pods, in four different types of packages. Fruits of local cultivars were obtained directly from the local farmers. The details of methodology followed in the investigation are described below.

3.1 Product development

3.2 Storage studies

3.1 PRODUCT DEVELOPMENT

Four products namely dried pulp, pulp powder, dried pieces of fruit and bottled fruit pieces in brine were made using standard techniques in conformity with FPO regulations (Appendix VI& VII). No preservatives have been used. The products were evaluated for biochemical and sensory qualities and consumer acceptance.

3.1.1 Methodology

3.1.1.1 Dried pulp

Fresh tender uniform size drumstick fruits were selected, washed and cleaned properly before cutting into pieces and then slit open into two halves. The half cut pieces were then scrapped off in order to get the pulp of drumstick fruits leaving the peel. The scrapped pulp were then subjected to drying in hot air oven at 60°C for 7-8 hours. Dried pulp were packed in four different packaging material and were stored at ambient temperature for six months.

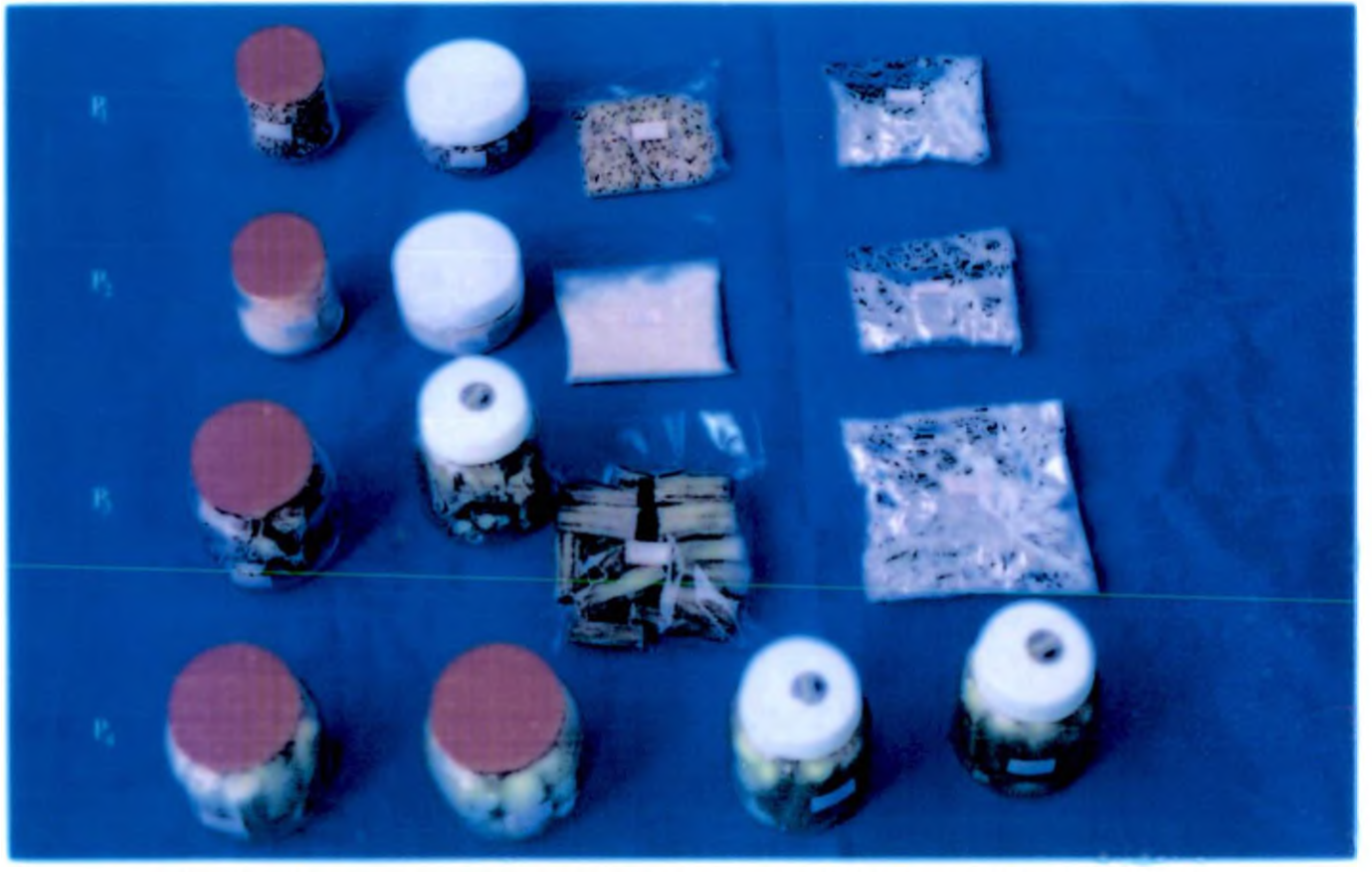

Plate 1. Diversified products prepared from drumstick (*Moringa oleifera* Lam.) fruit

Plate 2. Fresh scraped drumstick fruit pulp

Plate 3. Dried scraped drumstick fruit pulp

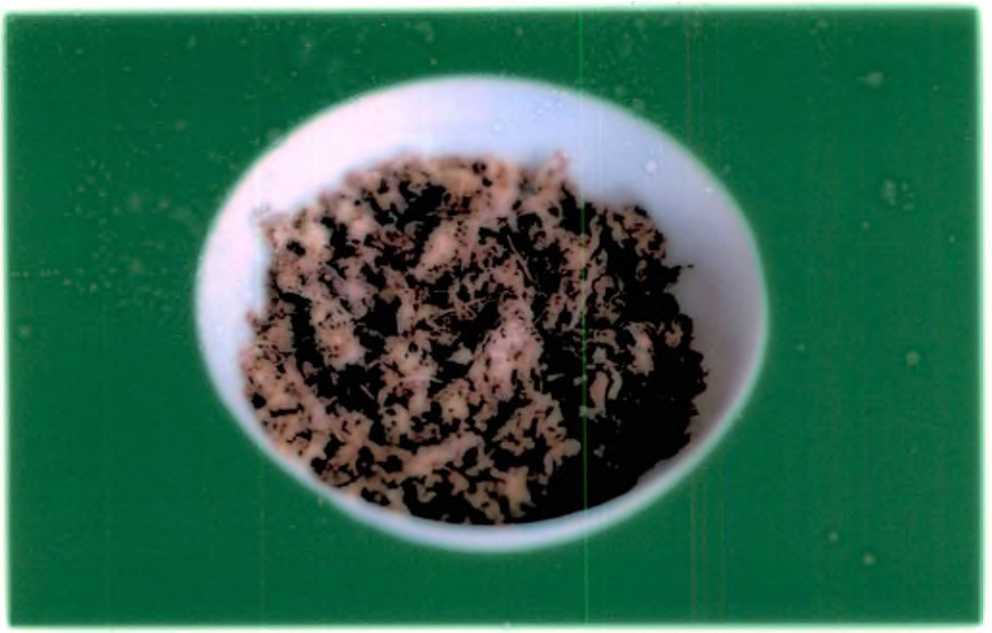

Plate 4. Fruit pulp after drying

Plate 5. Pulp powder after grinding

3.1.1.2 Pulp Powder

The dried pulp was ground in a grinder to obtain pulp powder and was packed in four different packaging materials and were stored at ambient temperature for six months.

3.1.1.3 Dried Pieces of Fruits

Tender uniform size fruits of drumstick were selected, washed and cleaned properly. Both ends were trimmed and then cut into two pieces and cut pieces were subjected to blanching. The blanched pieces of fruits were then cut into optimum size and kept in a hot air oven at 60°C for around 9-10 hours. The dried pieces of fruits were then packed in four different packaging materials and were stored at ambient temperature for six months.

3.1.1.4 Bottled Fruit Pieces in Brine

Tender fruits of uniform size were selected, washed, cut into pieces of two and blanched and then cut into standard size of fruit pieces (5 cm) and then packed in two packaging material containing two per cent salt solution and stored at ambient temperature for six months.

3.1.2 Biochemical Studies

3.1.2.1 Protein

Protein content (%) was estimated using microkjeldhal method (Sadasivam and Manikam, 1992).

3.1.2.2 Crude Fibre

Crude fibre (%) content of the products were determined by the method of A.O.A.C. (1984).

3.1.2.3 Total Carbohydrate

The total carbohydrate content was estimated by using phenol-sulphuric acid method (Sadasivam and Manickam, 1992).

3.1.2.4 Vitamin A

The estimation of vitamin A was done as per the method described by Srivastava and Kumar (2002).

3.1.2.5 Ascorbic Acid

Ascorbic acid content was estimated by the volumetric method (Sadasivam and Manickam, 1992). It was expressed as milligram per 100 g.

3.1.2.6 Fat

The estimation of fat was done as per the method described by Ranganna ((1986).

3.1.3 Sensory Evaluation and Consumer Acceptance

Sensory qualities of the products were assessed after development of the products. The judges for the sensory evaluation were selected from a group of students and teachers.

For scoring a four point scale was used, four representing the optimum for all quality characteristics and one representing poor quality. The major quality attributes included in the score card were colour, flavour, texture, taste and appearance as shown in Appendix I, II, III and IV. Sensory evaluation of the dried products were also done after reconstitution of the products according to the procedure given by Srivastava and Kumar (2002) as shown in Appendix V.

3.2 STORAGE STUDIES

The products were packed in different standard packages, stored for six months and were evaluated at monthly intervals for changes in biochemical and organoleptic qualities.

3.2.1 Types of products tried (P)

P_1 – Dried pulp

P_2 – Pulp powder

P_3 – Dried pieces of fruits

P_4 – Bottled fruit pieces in brine

3.2.2 Packaging Materials (T)

T_1 – Glass bottles (for all products)

T_2 – PET bottles (for all products)

T_3 – Polyethylene bags (dried products only)

T_4 – Aluminium foil (dried products only)

3.2.3 Duration of storage (D)

D_1 – 0 days

D_2 – 30 days

D_3 – 60 days

D_4 – 90 days

D_5 – 120 days

D_6 – 150 days

D_7 – 180 days

3.2.4 Experimental design

All the experiments were laid out in completely randomized design and analysed using variance technique (Gomez and Gomez, 1984).

Results

4. RESULTS

The result of the investigation on "Product development in drumstick (*Moringa oleifera* Lam.)" were statistically analysed and are presented under the following heads.

4.1 DRIED PRODUCTS

4.1.1 Changes in biochemical qualities during storage

4.1.1.1 Ascorbic acid

4.1.1.2 Fibre

4.1.1.3 Fat

4.1.1.4 Protein

4.1.1.5 Vitamin A

4.1.1.6 Total carbohydrate

4.1.2 1 Changes in organoleptic quality during storage

4.1.2.1 Dried pulp

4.1.2.2 Pulp powder

4.1.2.3 Dried pieces of fruits

4.1.2.4 Reconstituted dried products

4.2 BOTTLED FRUIT PIECES IN BRINE

4.2.1 Changes in biochemical qualities during storage

4.2.1.1 Ascorbic acid

4.2.1.2 Fibre

4.2.1.3 Fat

4.2.1.4 Protein

Table 1. Effect of products and storage period on ascorbic acid content (mg/100g) of dried products

	P_1	P_2	P_3	Mean
D_1	14.69	16.55	10.27	13.84
D_2	14.37	16.15	9.97	13.50
D_3	13.78	15.54	9.55	12.96
D_4	13.37	14.83	9.21	12.47
D_5	13.01	13.86	8.82	11. 90
D_6	12.57	12.83	8.45	11.28
D_7	11.22	10.95	8.18	10.12
CD (5 %)	D – 0.027	P x D – 0.046		

Table 2. Effect of packaging materials and storage period on ascorbic acid content (mg/100g) of dried products

	T_1	T_2	T_3	T_4	Mean
D_1	16.62	12.75	13.12	12.88	13.84
D_2	16.36	12.38	12.66	12.59	13.50
D_3	15.69	11.82	12.26	12.06	12.96
D_4	15.45	11.48	11.54	11.40	12.47
D_5	15.05	11.05	11.08	10.41	11. 90
D_6	14.27	10.37	10.56	9.93	11.28
D_7	13.43	9.41	9.51	8.14	10.12
CD (5 %)	D – 0.027	T x D – 0.054			

4.2.1.5 Vitamin A

4.2.1.6 Total carbohydrate

4.2.2 Changes in organoleptic quality during storage

4.2.2.1 Bottled fruit pieces in brine

4.1 DRIED PRODUCTS

The three dried products *viz*., dried pulp, pulp powder and dried pieces of fruit remained in good condition for analysis upto 180 days of storage, after which the products were completely spoiled due to microbial attack.

4.1.1 Changes in biochemical qualities during storage

Biochemical attributes of fresh drumstick fruits are given in Appendix-VIII

4.1.1.1 Ascorbic acid

Data on effect of product and storage on the ascorbic acid content of different dried products are presented in Table 1. It was noticed that there was significant reduction in ascorbic acid content in all the products consistently throughout the storage period from an initial mean value of 13.84 mg/100 g to 10.12 mg/100 g at the end of the storage period.

Data on effect of packaging material and storage period on the ascorbic acid content of different dried products are presented in Table 2. It was seen that ascorbic acid content of different dried products packed in four different packaging materials significantly reduced from an initial mean value of 13.84 mg/100 g to 10.12mg/100 g at the end of the storage period.

Data on the interaction effect of products packaging material and storage period on the ascorbic acid content of the three dried products are presented in Table 3.

Table 3. Effect of products, packaging materials and storage period on ascorbic acid content (mg/100g) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	19.75	13.79	13.51	11.71	14.69	18.79	14.39	15.76	17.26	16.55	11.26	10.07	10.07	9.69	10.27
D_2	19.59	13.37	13.08	11.44	14.37	18.49	14.00	15.12	16.98	16.15	10.99	9.76	9.76	9.37	9.97
D_3	18.79	12.73	12.78	10.82	13.78	17.82	13.25	14.66	16.44	15.54	10.47	9.45	9.34	8.94	9.55
D_4	18.47	12.23	12.46	10.31	13.37	17.56	12.98	13.11	15.67	14.83	10.26	9.25	9.08	8.24	9.21
D_5	17.96	11.97	12.09	10.01	13.01	17.18	12.79	12.35	13.11	13.86	9.99	8.38	8.79	8.12	8.82
D_6	17.40	11.82	11.67	9.39	12.57	16.12	11.12	11.59	12.49	12.83	9.28	8.18	8.43	7.90	8.45
D_7	16.33	10.24	10.23	8.08	11.22	15.12	9.99	10.16	8.53	10.95	8.82	7.97	8.14	7.80	8.18
CD (5%)	P x T x D - 0.093														

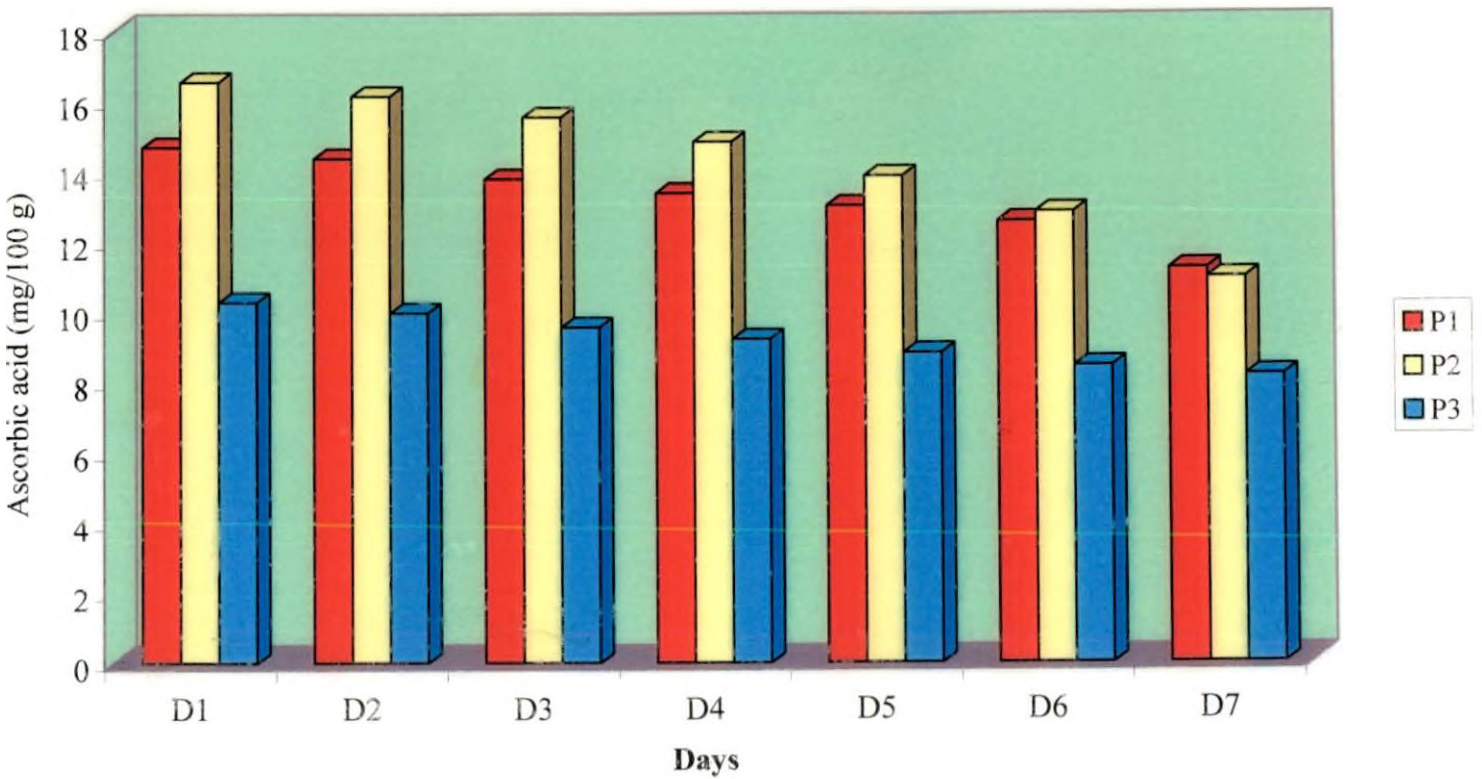

Fig. 1. Effect of products, packaging materials and storage period on ascorbic acid

Table 4. Effect of products and storage period on fibre content (g/100 g) of dried products

	P_1	P_2	P_3	Mean
D_1	11.24	7.09	22.27	13.53
D_2	11.24	7.09	22.27	13.53
D_3	11.22	7.08	22.26	13.52
D_4	11.21	7.08	22.25	13.52
D_5	11.19	7.07	22.25	13.51
D_6	11.18	7.06	22.24	13.49
D_7	11.17	7.06	22.23	13.48
CD (5 %)	D – 0.025	P x D – 0.043		

Table 5. Effect of packaging material and storage period on fibre content (g/100 g) of dried products

	T_1	T_2	T_3	T_4	Mean
D_1	13.18	13.69	13.84	13.42	13.53
D_2	13.18	13.69	13.84	13.42	13.53
D_3	13.17	13.67	13.83	13.42	13.52
D_4	13.17	13.67	13.82	13.41	13.52
D_5	13.16	13.66	13.80	13.39	13.51
D_6	13.15	13.64	13.80	13.38	13.49
D_7	13.15	13.63	13.79	13.38	13.48
CD (5 %)	D – 0.025	P x D – 0.050			

In dried pulp (P_1) packed in four different packaging materials, the highest ascorbic acid content (19.75 mg/100 g) at the beginning of the storage period was noticed in glass bottles (T_1) followed by 13.79 mg/100 g in PET bottles (T_2), 13.51 mg/100 g in polythene bags (T_3) and 11.71 mg/100 g in aluminium foil pouches (T_4). The monthly evaluation revealed that there was significant reduction in ascorbic acid content throughout the storage period in all the packaging materials. At the end of the storage period the corresponding values were 16.33 mg/100 g, 10.24 mg/100 g, 10.23 mg/100 g and 8.08 mg/100 g respectively.

Pulp powder (P_2) also showed a similar trend as far as ascorbic acid content is concerned. It showed an initial value of 18.79 mg/100 g, 14.39 mg/100 g, 15.76 mg/100 g and 17.26 mg/100 g respectively for T_1, T_2, T_3 and T_4. Ascorbic acid content decreased consistently and significantly throughout the storage period showing the values as 15.12 mg/100 g, 9.99 mg/100 g, 10.16 mg/100 g and 8.53 mg/100 g respectively for T_1, T_2, T_3 and T_4.

In dried fruit pieces the highest ascorbic acid content was recorded in T_1 (11.26 mg/100 g) followed by T_2 and T_3 (10.07 mg/100 g) and T_4 (9.69 mg/100 g) at the beginning of the storage period. Ascorbic acid content decreased significantly over the storage period, giving the final values as 8.82 mg/100 g, 7.97 mg/100 g, 8.14 mg/100 g and 7.88 mg/100 g for T_1, T_2, T_3 and T_4 respectively.

The highest ascorbic acid content of 19.75 mg/100 g was recorded in $P_1T_1D_1$ whereas the lowest of 7.80 mg/100 g was recorded in $P_3T_4D_7$.

4.1.1.2 Fibre

Data on the effect of products and storage period on fibre content are presented in Table 4. The highest mean fibre content of 13.53 g/100 g was recorded in the beginning of the storage period and the lowest of 13.48 g/100g at the end. However there was no significant change in the fibre

Table 6. Effect of products, packaging materials and storage period on fibre content (g/100g) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	10.33	11.69	11.72	11.21	11.24	7.23	7.11	7.05	7.00	7.09	22.00	22.75	22.75	22.05	22.27
D_2	10.33	11.69	11.71	11.21	11.24	7.23	7.11	7.05	7.00	7.09	22.00	22.27	22.75	22.05	22.27
D_3	10.31	11.68	11.69	11.20	11.22	7.21	7.09	7.03	7.00	7.08	22.00	22.25	22.75	22.04	22.26
D_4	10.31	11.67	11.68	11.18	11.21	7.09	7.03	6.99	7.08	7.08	21.99	22.25	22.73	22.04	22.25
D_5	10.29	11.63	11.66	11.18	11.19	7.09	7.01	6.98	7.07	7.07	21.99	22.25	22.73	22.02	22.25
D_6	10.29	11.62	11.66	11.16	11.18	7.07	7.01	6.98	7.06	7.06	21.97	22.23	22.73	22.02	22.24
D_7	10.28	11.60	11.65	11.15	11.17	7.07	7.01	6.98	7.06	7.06	21.97	22.23	22.71	22.02	22.23
CD (5%)	P x T x D - 0.086														

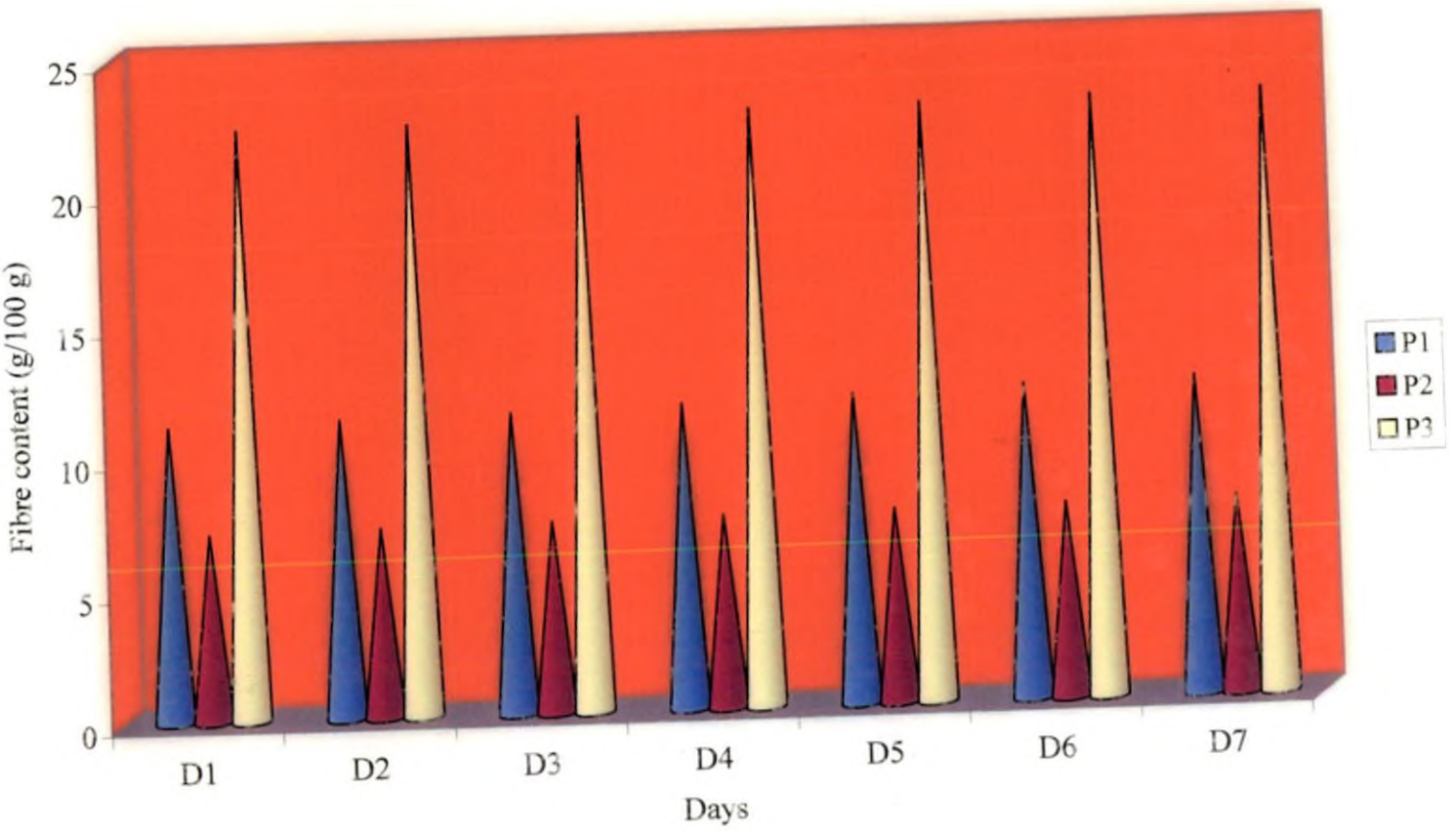

Fig. 2. Effect of products, packaging materials and storage period on fibre content

content of dried products over the storage period, though there was significant difference in fibre content between the products. The highest value of 22.27 g/100g recorded at D_1 was in P_3 followed by 11.24 g/100 g in P_1 and 7.09 g/100 g in P_2.

Data on the effect of packaging materials and storage period on the fibre content are presented in Table 5. The mean values showed that there was no significant changes in the fibre content over the storage period. However the different packaging material showed a difference in the fibre content in the dried products. The highest fibre content at D_1 was recorded as 13.84 g/100g in T_3 followed by 13.69 g/100 g in T_2, 13.42 g/100 g in T_4 and 13.18 g/100 g in T_1.

Data on interaction effect of products, packaging materials and storage period on the fibre content are presented in Table 6. The highest mean fibre content at the beginning of the storage period was observed in P_3 (22.27 g/100g) followed by P_1 (11.24 g/100g) and P_2 (7.09 g/100g). The corresponding values at the end of the storage period were noticed as 22.23 g/100g, 11.17 g/100 g and 7.06 g/100g respectively. It was observed that there was no significant difference in the fibre content between the packaging materials in all the products. It was also noticed that the fibre content did not change significantly during the storage period in all the packaging materials for all the products.

4.1.1.3 Fat

Data on the effect of products and storage period on the fat content are presented in Table 7. The mean values of fat content in different dried products showed that fat content reduced significantly every month till the end of the storage period from an initial value of 0.458 g/100 g at the beginning to 0.268 g/100 g at the end of the storage period.

Data on the effect of packaging materials and storage period on the fat content in different dried products are presented in Table 8. It had been

Table 7. Effect of products and storage period on fat content (g/100 g) of dried products

	P_1	P_2	P_3	Mean
D_1	0.358	0.219	0.797	0.458
D_2	0.357	0.215	0.792	0.455
D_3	0.339	0.213	0.782	0.445
D_4	0.255	0.210	0.768	0.411
D_5	0.209	0.206	0.707	0.374
D_6	0.176	0.136	0.664	0.325
D_7	0.130	0.112	0.561	0.268
CD (5 %)	D – 0.002	P x D – 0.003		

Table 8. Effect of packaging materials and storage period on fat content (g/100 g) of dried products

Days	T_1	T_2	T_3	T_4	Mean
D_1	0.472	0.465	0.468	0.426	0.458
D_2	0.466	0.462	0.465	0.426	0.455
D_3	0.460	0.457	0.438	0.425	0.445
D_4	0.405	0.416	0.426	0.397	0.411
D_5	0.366	0.387	0.380	0.364	0.374
D_6	0.331	0.314	0.313	0.344	0.325
D_7	0.281	0.270	0.271	0.249	0.268
CD (5 %)	D – 0.002	T x D – 0.004			

observed that the fat content of all the products in different packaging materials significantly reduced every month from an initial mean value of 0.458 g/100g to 0.268 g/100g at the end of the storage period.

Data on the effect of products, packaging materials and storage period on fat content of different dried products are presented in Table 9.

In dried pulp (P_1) no significant change in fat content was noticed till the fourth month with respect to all the packaging materials except in T_3 where a significant change was noticed in the third months. There was significant monthly reduction in fat content from fourth month onwards till the end of the storage in products in all the packaging materials except in T_1 and T_2 where fat content in the fifth months were on par with that of the fourth months. Fat content in P_1T_1 reduced from 0.382 g/100g at the beginning of the storage period to 0.158 g/100 g at the end while the corresponding values in T_2 were 0.381 g/100g and 0.137 g/100g, in T_3 0.387 g/100g and 0.130 g/100g in T_4 0.283 g/100g and 0.093 g/100g.

Fat content in dried pulp powder (P_2) did not change significantly with respect to all the packaging materials until the sixth months. Significant reduction in fat content was observed both at the beginning of the sixth months and at the end of the storage period with respect to all the packaging material. The highest value of fat content in P_2 was observed in T_1D_1 (0.226 g/100g) followed by T_3 (0.219 g/100g) and T_2 and T_4 each having a value of 0.215 g/100g. The values at the end of the storage period were observed as 0.098 g/100g (T_1), 0.095 g/100g (T_2), 0.098 g/100g (T_3) and 0.158 g/100g (T_4).

Fat content in dried pieces (P_3) with respect to T_1 was found decreasing significantly at the third and fifth month and also at the end of the storage period whereas that with respect to T_2 was found decreasing significantly every month from fourth months onwards. With T_3 the first significant reduction in fat content was noticed at the third month followed by no significant change in the fourth months and thereafter significant

Table 9. Effect of products, packaging materials and storage period on fat content (g/100 g) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	0.382	0.381	0.387	0.283	0.358	0.226	0.215	0.219	0.215	0.219	0.799	0.795	0.799	0.795	0.797
D_2	0.379	0.379	0.387	0.283	0.357	0.221	0.212	0.215	0.213	0.215	0.796	0.789	0.794	0.791	0.792
D_3	0.378	0.372	0.326	0.280	0.339	0.220	0.209	0.212	0.212	0.213	0.781	0.789	0.777	0.782	0.782
D_4	0.219	0.260	0.302	0.240	0.255	0.214	0.207	0.210	0.208	0.210	0.781	0.780	0.766	0.743	0.768
D_5	0.190	0.255	0.198	0.193	0.209	0.209	0.205	0.206	0.205	0.206	0.699	0.701	0.735	0.694	0.707
D_6	0.189	0.149	0.187	0.179	0.176	0.110	0.104	0.155	0.174	0.136	0.694	0.687	0.596	0.678	0.664
D_7	0.158	0.137	0.130	0.093	0.130	0.098	0.095	0.098	0.158	0.112	0.586	0.579	0.584	0.497	0.561
CD (5%)	P x T x D - 0.007														

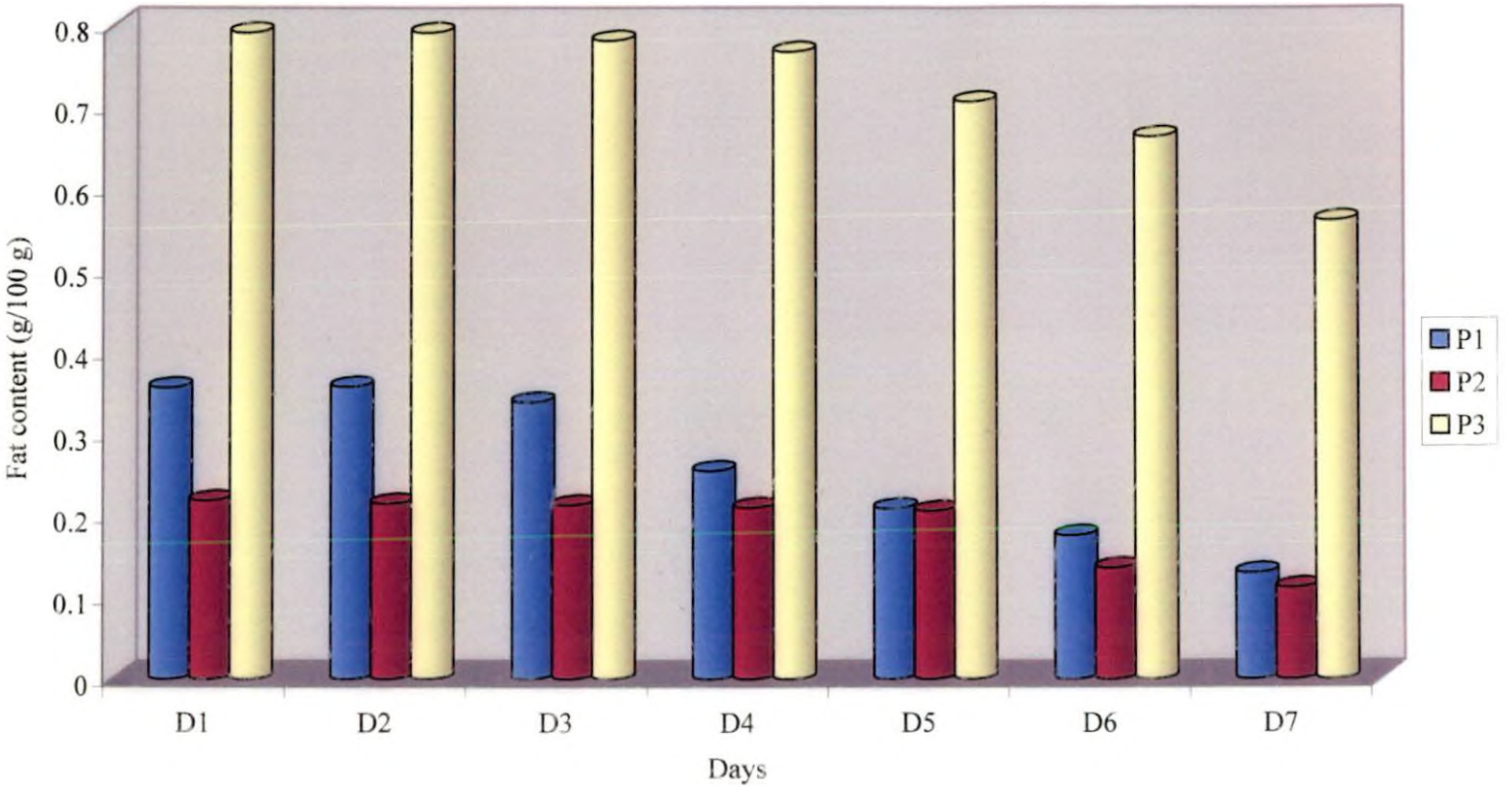

Fig. 3. Effect of products, packaging materials and storage period on fat content

monthly reduction till the end of the storage period. T_3 and T_4 showed a common trend of significant monthly reduction in fat content from the third month till the end of the storage period. The highest value of fat content in P_3 was noticed in T_1 and T_3 (0.799 g/100g) followed by T_2 and T_4 (0.795 g/100g) at the beginning of the storage period. At the end of the storage the values were seen as 0.586 g/100g (T_1), 0.579 g/100g (T_2), 0.584 g/100g (T_3) and 6.497 g/100g (T_4).

The highest mean fat content among all the products was observed as 0.797 g/100g in P_3 followed by 0.358 g/100g in P_1 and 0.219 g/100g in P_2 at the beginning of the storage period. The same trend was also noticed at the end of the storage period where the corresponding values were 0.561 g/100g (P_3), 0.130 g/100g (P_1) and 0.112 g/100g (P_2).

4.1.1.4 Protein

Data on effect of products and storage period on the protein content are presented in Table 10. The mean values of all the products showed that there was significant monthly reduction in protein content from the beginning of the third month till the end of the storage period. The initial mean value was 2.20 g/100g and the mean value at the end of the storage period was 1.25 g/100g.

Data on the effect of packaging materials and storage period on protein content are presented in Table 11. The mean values of protein content in all the products with respect to different packaging materials was found to decrease significantly every month from fourth month onwards till the end of the storage period. At the beginning of the storage period the mean values was 2.20 g/100g while at the end of the storage period it was 1.25 g/100g.

Data on the effect of products, packaging materials and storage period on protein content are presented in Table 12. The highest value of protein content at the beginning of the storage period was noticed in P_3T_2 and P_3T_3

Table 10. Effect of products and storage period on protein content (g/100 g) of dried products

	P_1	P_2	P_3	Mean
D_1	2.24	2.00	2.35	2.20
D_2	2.23	2.00	2.34	2.19
D_3	2.14	1.65	1.99	1.93
D_4	1.89	1.56	1.91	1.79
D_5	1.88	1.39	1.47	1.58
D_6	1.70	1.12	1.22	1.35
D_7	1.69	1.03	1.04	1.25
CD (5 %)	D – 0.046	P x D – 0.081		

Table 11. Effect of packaging materials and storage period on protein content (g/100 g) of dried products

Days	T_1	T_2	T_3	T_4	Mean
D_1	2.31	2.30	2.22	1.97	2.20
D_2	2.30	2.29	2.21	1.96	2.19
D_3	1.96	2.06	2.09	1.62	1.93
D_4	1.85	1.84	1.85	1.61	1.79
D_5	1.49	1.49	1.73	1.61	1.58
D_6	1.36	1.37	1.38	1.28	1.34
D_7	1.35	1.35	1.26	1.03	1.25
CD (5 %)	D – 0.046	T x D – 0.094			

Table 12. Effect of products, packaging materials and storage period on protein content (g/100 g) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	2.38	2.36	2.12	2.09	2.24	2.10	2.10	2.10	1.73	2.00	2.44	2.45	2.45	2.07	2.35
D_2	2.38	2.35	2.09	2.09	2.23	2.10	2.09	2.09	1.72	2.00	2.43	2.44	2.44	2.06	2.34
D_3	2.37	2.35	2.09	1.75	2.14	1.75	1.74	1.73	1.38	1.65	1.74	2.07	2.44	1.73	1.99
D_4	2.06	2.03	1.75	1.73	1.89	1.74	1.40	1.72	1.37	1.56	1.74	2.07	2.08	1.73	1.91
D_5	2.03	2.03	1.75	1.72	1.88	1.40	1.39	1.40	1.37	1.39	1.04	1.05	2.07	1.73	1.47
D_6	2.02	2.02	1.73	1.03	1.70	1.02	1.03	1.37	1.03	1.12	1.03	1.05	1.05	1.73	1.22
D_7	2.02	2.01	1.72	1.02	1.69	1.02	1.02	1.03	1.03	1.03	1.02	1.03	1.05	1.04	1.04
CD (5%)	P x T x D - 0.162														

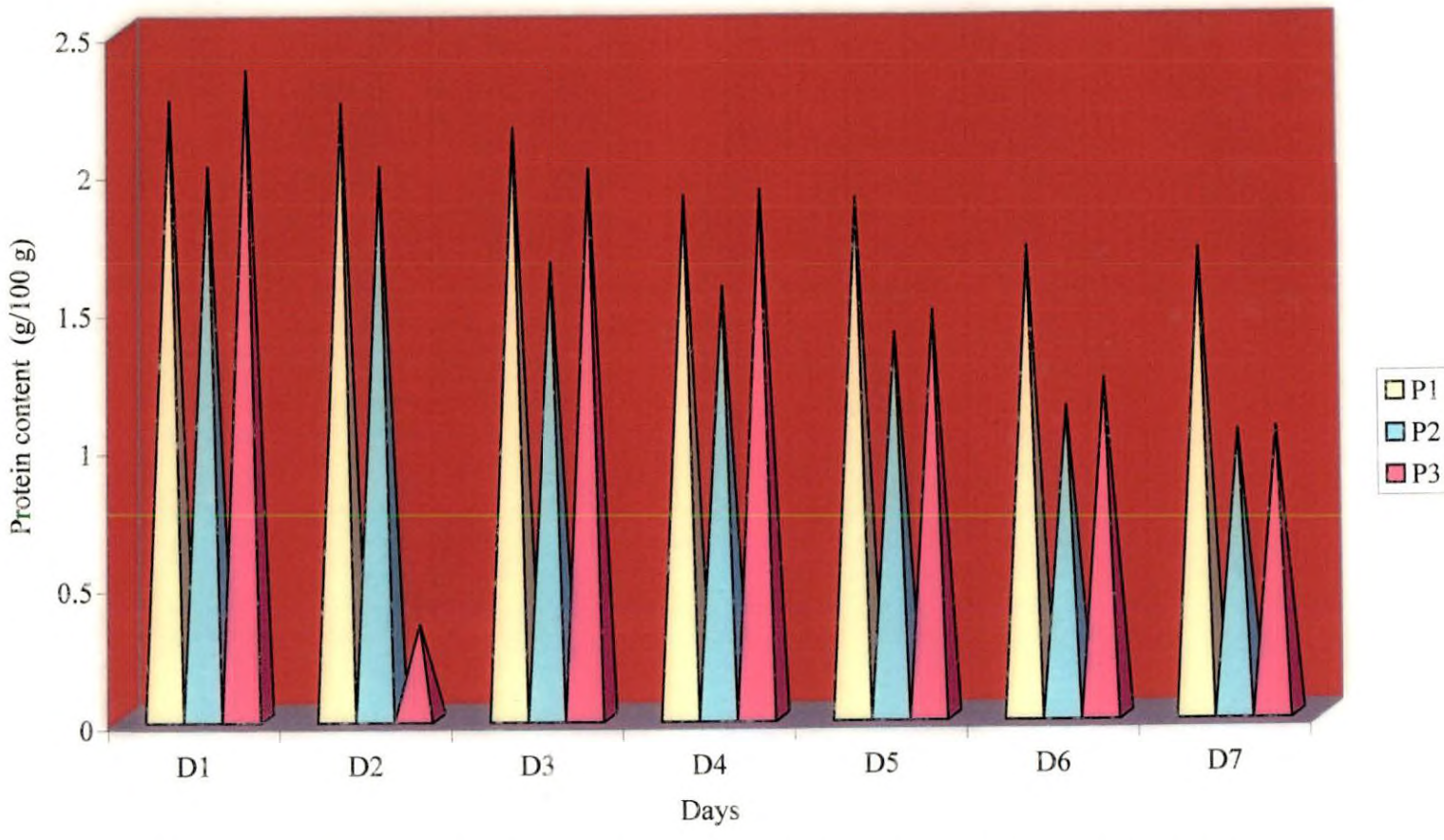

Fig. 4. Effect of products, packaging materials and storage period on protein content

(2.45 g/100g) followed by 2.44 g/100g in P_3T_1, 2.38 g/100g in P_1T_1 and 2.36 g/100g in P_1T_2. The lowest value at the beginning of the storage period was noticed in P_2T_4 (1.73 g/100g).

In dried pulp (P_1) a significant reduction in protein content with respect to T_1, T_2 and T_3 were noticed only at the beginning of the fourth months. Thereafter the values did not change significantly till the end of the storage period. With respect to P_1T_4 significant reduction was noticed in the beginning of third month as well as sixth months. The mean protein content of P_1 was found to reduce from an initial value of 2.24 g/100g to 1.69 g/100g at the end of the storage period.

The protein content in dried pulp powder showed no significant change till the end of the second month of storage. Protein content with respect to all the packaging materials showed significant change from third month onwards. Thereafter significant change was noticed in P_2T_1 in the fifth and sixth months, in P_2T_2 in fourth and sixth months, in P_2T_3 fifth and sixth months and in P_2T_4 only in the sixth months. In P_2, at the beginning of the storage period, the highest protein content of 2.10 g/100g was observed in T_1, T_2 and T_3 followed by 1.73 g/100g in T_4. These values were reduced to 1.02 g/100g each in T_1 and T_2 and 1.03 g/100g each in T_3 and T_4. The highest mean value of 2.0 g/100g got reduced to 1.03 g/100g with significant changes noted in the third, fifth and sixth months.

In dried fruit pieces (P_3) the highest protein content at the beginning of the storage period was noticed in T_2 and T_3 (2.45 g/100g) followed by T_1 (2.44 g/100g) and in T_4 (2.07 g/100g). The protein content in P_3 at the end of the storage period were observed as 1.02 g/100g (T_1), 1.03 g/100g (T_2), 1.05 g/100g (T_3) and 1.04 g/100g (T_4). The highest mean value of 2.35 g/100g at the beginning of the storage period was found to reduce to 1.04 g/100g at the end of the storage period with significant reduction noted in the fourth, fifth and sixth months and also at the end of the storage period. Significant reduction in protein content with respect to P_3T_1 and P_3T_2 were noted in third

Table 13. Effect of products and storage period on vitamin A content (IU) of dried products

	P_1	P_2	P_3	Mean
D_1	125.95	120.85	137.14	127.98
D_2	125.65	120.44	136.75	127.61
D_3	125.35	120.19	136.31	127.28
D_4	124.97	119.84	135.97	126.93
D_5	124.68	119.53	135.57	126.59
D_6	124.31	119.13	135.26	126.23
D_7	124.03	118.82	134.81	125.89
CD (5 %)	D – 0.035	P x D – 0.061		

Table 14. Effect of packaging materials and storage period on vitamin A content (IU) of dried products

Days	T_1	T_2	T_3	T_4	Mean
D_1	132.75	126.29	124.76	128.13	127.98
D_2	132.18	125.83	124.56	127.87	127.61
D_3	131.78	125.54	124.27	127.54	127.28
D_4	131.33	125.26	123.94	127.18	126.93
D_5	131.08	125.00	123.46	126.83	126.59
D_6	130.72	124.60	123.14	126.46	126.23
D_7	130.38	124.28	122.83	126.07	125.89
CD (5 %)	D – 0.035	T x D – 0.070			

Table 15. Effect of products, packaging materials and storage period on vitamin A content (IU) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	132.11	123.98	115.59	132.12	125.95	125.73	119.96	118.69	119.05	120.85	140.43	134.93	139.98	133.23	137.14
D_2	131.74	123.72	115.34	131.79	125.65	124.90	119.37	118.59	118.89	120.44	139.92	134.41	139.74	132.94	136.75
D_3	131.41	123.33	115.02	131.64	125.35	124.71	119.06	118.41	118.59	120.19	139.23	134.23	139.39	132.39	136.31
D_4	131.00	123.00	114.60	131.29	124.97	124.03	118.86	118.22	118.23	119.84	138.94	133.95	138.99	132.00	135.97
D_5	130.73	122.74	114.26	131.00	124.68	123.92	118.59	117.92	117.70	119.53	138.62	133.72	138.22	131.73	135.57
D_6	130.30	122.25	113.93	130.76	124.31	123.43	118.21	117.48	117.41	119.13	138.43	133.38	138.00	131.23	135.26
D_7	130.05	121.99	113.77	130.32	124.03	123.21	117.94	117.20	116.94	118.82	137.87	132.90	137.53	130.93	134.81
CD (5%)		P x T x D - 0.121													

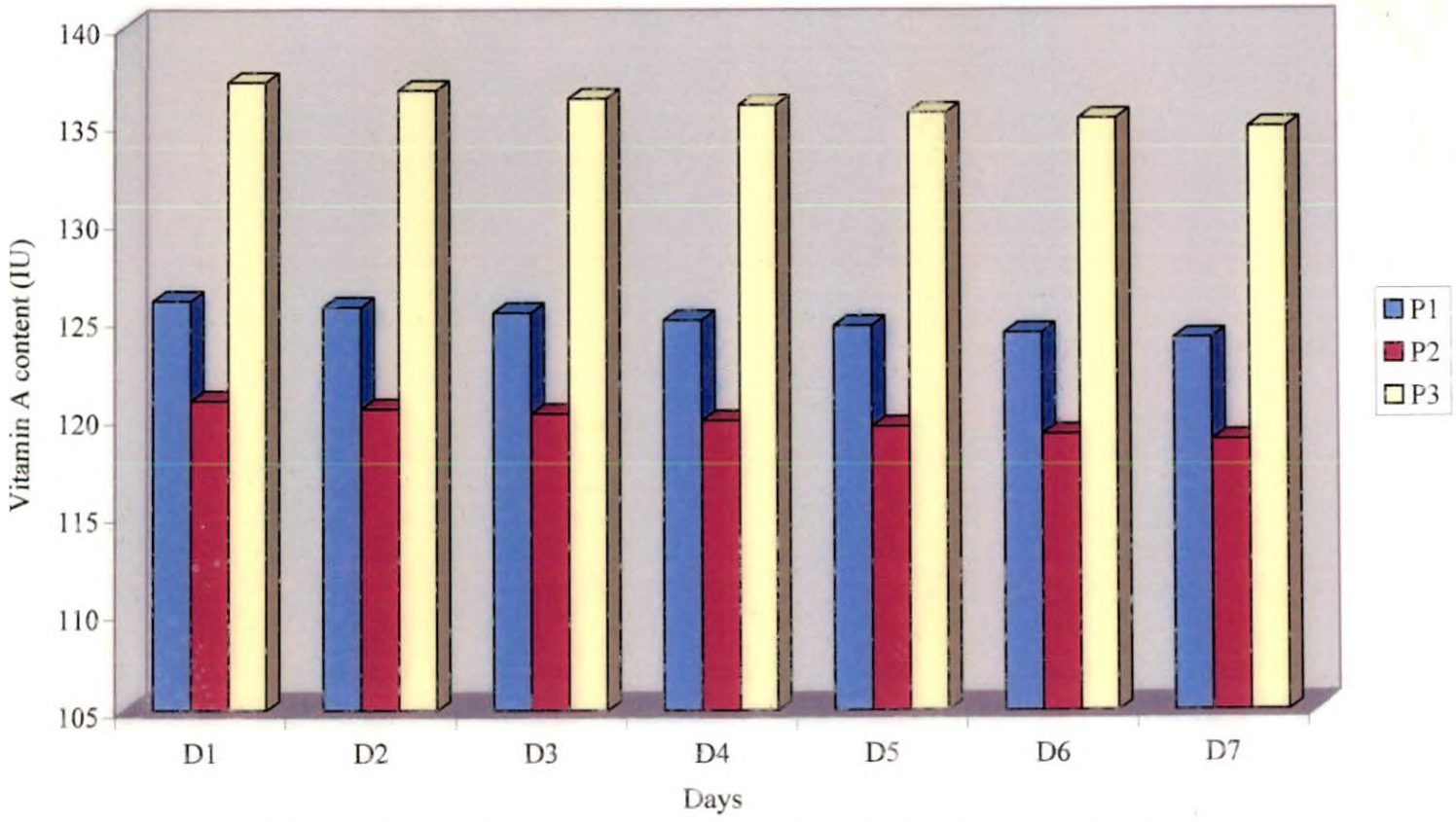

Fig. 5. Effect of products, packaging materials and storage period on vitamin A content

and fifth months whereas that in the case of P_3T_3 were in the fourth and sixth month and for P_3T_4 at the beginning of third month and at the end of storage period.

4.1.1.5 Vitamin A

Data on effect of products and storage period on vitamin A content are presented in Table 13. It was observed that vitamin A content significantly reduced every month throughout the storage period from an initial mean value of 127.98 IU to 125.89 IU at the end of the storage.

Data on effect and packaging materials and storage period on vitamin A content are presented in Table 14. Vitamin A content of the different dried products packed in different packaging materials showed a consistent monthly reduction and the change was significant. The mean value of vitamin A content at the beginning of the storage period was 127.98 IU and that at the end of the storage period was 125.89 IU.

Data on effect of products, packaging materials and storage period on vitamin A content of dried products are presented in Table 15. All the three different dried products with respect to the four packaging materials showed a decreasing tendency as far as vitamin A content is concerned. The change was noticed to be significant every month.

In dried pulp (P_1) the highest vitamin A content at the beginning of the storage period was found in T_4 (132.12 IU) followed by T_1 (132.11 IU), T_2 (123.98 IU) and T_3 (115.59 IU). The same pattern was observed at the end of the storage period where the values were noted as 130.32 IU (T_4) followed by 130.05 IU (T_1), 121.99 IU (T_2) and 113.77 IU (T_3).

In dried pulp powder (P_2), among the four different packaging material used, the highest vitamin A content was noticed in T_1 (125.73 IU) followed by T_2 (119.96 IU), T_4 (119.05 IU) and T_3 (118.69 IU). These initial values were reduced to 123.21 IU, 117.94 IU, 116.94 IU and 117.20 IU respectively at the end of the storage period.

Table 16. Effect of products and storage period on total carbohydrate content (g/100 g) of dried products

	P_1	P_2	P_3	Mean
D_1	10.26	9.93	7.83	9.34
D_2	9.85	9.50	7.59	8.98
D_3	9.61	9.04	7.43	8.69
D_4	9.32	8.74	7.16	8.41
D_5	8.83	8.40	6.97	8.06
D_6	8.54	8.02	6.68	7.75
D_7	7.83	7.42	6.37	7.21
CD (5 %)	D – 0.044	P x D – 0.076		

Table 17. Effect of packaging materials and storage period on total carbohydrate content (g/100 g) of dried products

Days	T_1	T_2	T_3	T_4	Mean
D_1	8.53	7.49	10.02	11.32	9.34
D_2	8.23	6.87	9.73	11.09	8.98
D_3	7.93	6.69	9.34	10.81	8.69
D_4	7.61	6.42	9.00	10.60	8.41
D_5	7.10	6.22	8.71	10.22	8.06
D_6	6.82	5.96	8.46	9.76	7.75
D_7	6.33	5.40	8.03	9.07	7.21
CD (5 %)	D – 0.044	T x D – 0.087			

Among the dried pieces packed in different packaging materials, the highest initial vitamin A content was observed in T_1 (140.43 IU) followed by T_3 (139.98 IU), T_2 (134.93 IU) and T_4 (133.23 IU). At the end of the storage period the highest vitamin A content in dried pieces with respect to different packaging materials was in T_1 (137.87 IU) followed by T_3 (137.53 IU), T_2 (132.90 IU) and T_4 (130.93 IU).

4.1.1.6 Total carbohydrate

Data on effect of products and storage period on carbohydrate content of the dried products are presented in Table 16. The data showed that total carbohydrate content decreased consistently every month during the storage period. It was evident from the mean value that this changes were significant every month. The initial mean value of 9.34 g/100 g was found to reduce to 7.21 g/100 g at the end of the storage period.

Data on the effect of packaging materials and storage period on total carbohydrate content of dried products are presented in Table 17. A decreasing tendency in total carbohydrate content of dried products with respect to the different packaging materials was noted. These reduction were consistent and significant every month. The highest mean total carbohydrate content of 9.34 g/100g was reduced to 7.21 g/100g at the end of the storage period.

Data on the effect of products, packaging materials and storage period on total carbohydrate of the three dried products are presented in Table 18. The mean values revealed that among the three dried products, dried pulp (P_1) had the highest total carbohydrate content of 10.26 g/100g followed by pulp powder (P_2 – 9.93 g/100g) and dried fruit pieces (P_3 – 7.83 g/100g). The mean value also showed that total carbohydrate content in all the three dried products reduced significantly every month. At the end of the storage period these products had a total carbohydrate content of 7.83 g/100g (P_1), 7.42 g/100g (P_2) and 6.37 g/100g (P_3).

Table 18. Effect of products, packaging materials and storage period on total carbohydrate content (g/100 g) of dried products

	P_1					P_2					P_3				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
D_1	11.87	10.30	8.53	10.33	10.26	7.70	7.03	11.20	13.80	9.93	6.03	5.13	10.33	9.83	7.83
D_2	11.57	9.27	8.43	10.13	9.85	7.40	6.63	10.53	13.43	9.50	5.73	4.70	10.23	9.70	7.59
D_3	11.27	9.23	8.10	9.83	9.61	6.87	6.23	9.96	13.10	9.04	5.67	4.60	9.96	9.50	7.43
D_4	10.77	8.87	7.93	9.70	9.32	6.67	5.93	9.43	12.93	8.74	5.40	4.47	9.62	9.16	7.16
D_5	9.67	8.63	7.67	9.33	8.83	6.33	5.73	9.14	12.40	8.40	5.30	4.30	9.33	8.93	6.97
D_6	9.36	8.53	7.52	8.76	8.54	5.93	5.33	8.83	11.97	8.02	5.16	4.00	9.00	8.57	6.68
D_7	8.97	7.73	7.00	7.63	7.83	5.13	4.73	8.47	11.33	7.42	4.90	3.73	8.63	8.23	6.37
CD (5%)	P x T x D - 0.152														

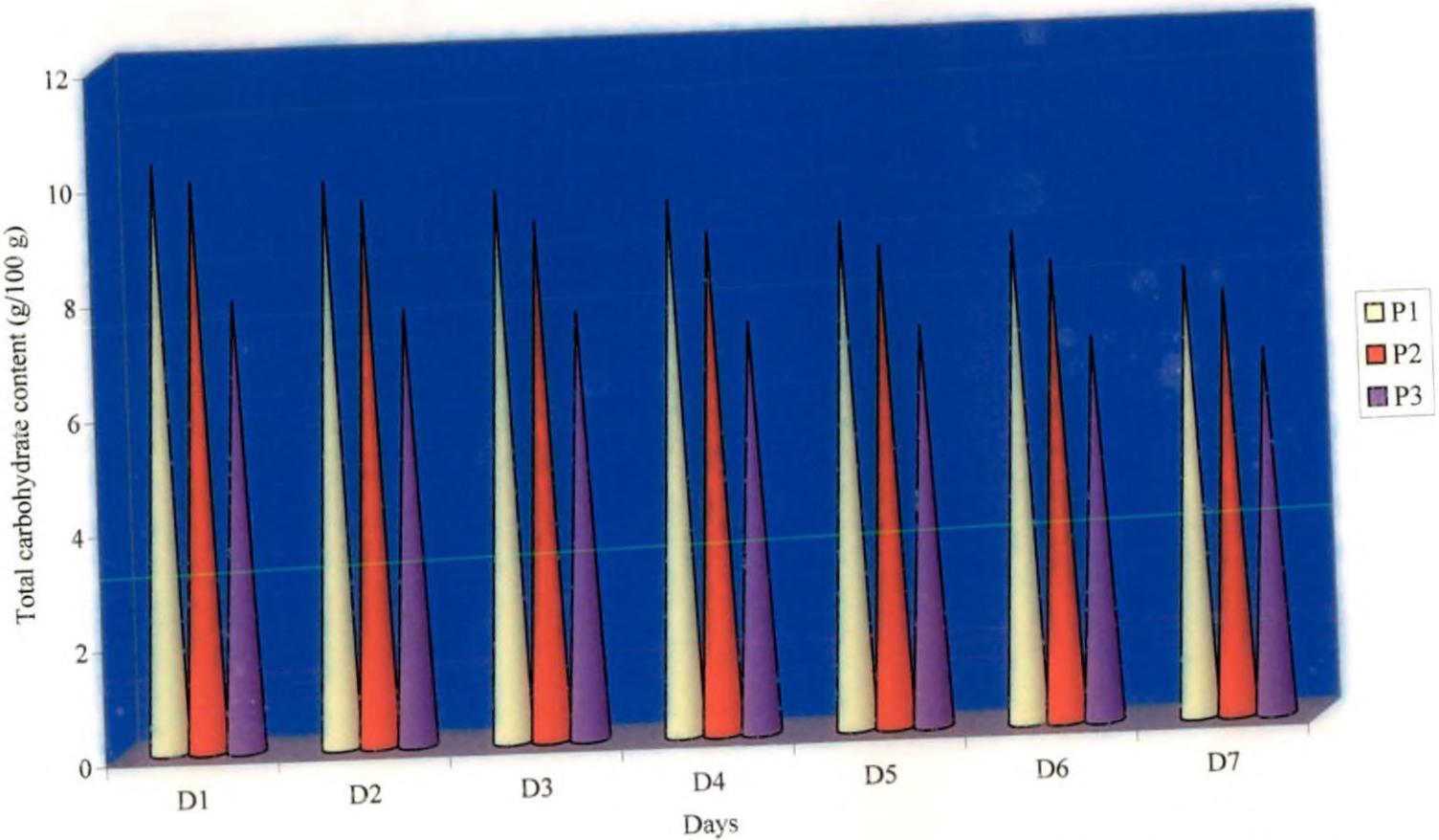

Fig. 6. Effect of products, packaging materials and storage period on total carbohydrate content

In P_1, among the different packaging material T_1 recorded the highest total carbohydrate of 11.87 g/100g at the beginning of the storage period followed by T_4 (10.33 g/100g), T_2 (10.30 g/100g) and T_3 (8.53 g/100g). In P_1T_1 the total carbohydrate content of 11.87 g/100g at the beginning of storage period reduced significantly every month to 8.97 g/100g at the end of the storage period. In P_1T_2 total carbohydrate content reduced from 10.30 g/100g at the beginning to 7.73 g/100g at the end of the storage period, the changes being not significant in the third and sixth months. In P_1T_3, the changes in the second and sixth months were not significant and the total carbohydrate content at the beginning of storage period was found to reduce from 8.53 g/100g to 7.00 g/100g at the end of the storage period. P_1T_4 also showed the same trend of significant monthly reduction and that of T_1 showing a reduction from 10.33 g/100g to 7.63 g/100g.

Pulp powder (P_2) packed in the four different packaging materials showed a significant monthly reduction in total carbohydrate content. The highest carbohydrate content at the beginning of the storage period was recorded in T_4 (13.80 g/100 g) followed by T_3 (11.20 g/100 g), T_1 (7.70 g/100 g) and T_2 (7.03 g/100 g). The same trend was maintained at the end of the storage period also with the highest value for T_4 (11.33 g/100 g) followed by T_3 (8.47 g/100 g), T_1 (5.13 g/100 g) and T_2 (4.73 g/100 g).

The highest total carbohydrate content in dried pieces (P_3) at the beginning of the storage period was recorded in T_3 (10.33 g/100 g) followed by T_4 (9.83 g/100 g), T_1 (6.03 g/100 g) and T_2 (5.13 g/100 g). A similar trend was observed at the end of the storage period also with the total carbohydrate content noted as 8.63 g/100 g (T_3), 8.23 g/100 g (T_4), 4.90 g/100 g (T_1) and 3.73 g/100 g (T_2). In P_3T_1 there was significant monthly reduction in total carbohydrate content except in the third, fifth and sixth months while that in P_3T_2 was observed except in the third and fourth months. Significant monthly reduction in total carbohydrate was also observed in P_3T_3 and P_3T_4 except in the second month.

Table 19. Effects of storage period and packaging materials on organoleptic qualities of dried pulp (mean score obtained out of four)

	D_1				D_2				D_3			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE												
VG	2.8	1.1	0.0	0.5	2.8	1.1	0.5	0.0	2.8	1.1	0.5	0.0
G	0.8	1.7	1.2	0.8	0.8	1.2	0.8	0.5	0.8	1.2	0.8	0.4
F	0.0	0.5	1.1	0.8	0.0	0.5	0.8	1.4	0.0	0.5	0.8	1.4
P	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1
Total	**3.6**	**3.3**	**2.3**	**2.2**	**3.6**	**2.8**	**2.2**	**1.9**	**3.6**	**2.8**	**2.2**	**1.9**
COLOUR												
VG	1.1	0.5	0.0	0.0	1.1	0.5	0.0	0.0	0.5	0.5	0.0	0.0
G	1.2	1.7	1.2	0.8	1.2	1.7	1.2	0.8	1.2	1.7	1.2	0.8
F	0.5	0.5	1.1	1.4	0.5	0.5	1.1	1.4	0.8	0.2	0.8	1.1
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Total	**2.8**	**2.7**	**2.3**	**2.2**	**2.8**	**2.7**	**2.3**	**2.2**	**2.5**	**2.5**	**2.1**	**2.0**
FLAVOUR												
VG	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
G	2.1	1.7	1.2	0.8	1.7	1.2	1.2	0.8	1.7	1.2	1.2	1.2
F	0.2	0.5	0.8	0.8	0.2	0.0	0.8	0.8	0.2	0.0	1.1	0.8
P	0.0	0.0	0.0	0.1	0.1	0.4	0.0	0.1	0.1	0.4	0.0	0.1
Total	**2.8**	**2.7**	**2.5**	**2.2**	**2.5**	**2.1**	**2.5**	**2.2**	**2.5**	**2.1**	**2.3**	**2.1**
TASTE												
VG	3.4	2.2	2.8	0.5	3.4	2.2	2.8	0.5	2.2	1.7	1.7	0.5
G	0.4	1.2	0.8	2.1	0.4	1.2	1.2	1.7	1.2	1.2	0.8	1.2
F	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.5	0.0	0.2	0.5	0.2
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	**3.8**	**3.4**	**3.6**	**2.8**	**3.8**	**3.4**	**3.0**	**2.7**	**3.4**	**3.1**	**2.0**	**2.1**
TEXTURE												
VG	1.7	0.5	1.1	0.5	0.0	0.5	1.1	0.0	0.0	0.0	0.0	0.0
G	0.8	1.2	1.7	0.4	0.8	1.2	1.7	0.4	0.8	1.2	1.7	0.4
F	0.2	0.8	0.0	1.4	1.1	0.8	0.0	1.1	0.0	0.8	0.8	0.8
P	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.2	0.7	0.1	0.0	0.4
Total	**2.7**	**2.7**	**2.9**	**2.3**	**2.0**	**2.5**	**2.9**	**1.7**	**1.5**	**2.1**	**1.5**	**1.6**

VG – Very good, G – Good, F – Fair, P - Poor

Table 19. Continued

	D_4				D_5				D_6				D_7			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE																
VG	2.2	1.1	0.0	0.0	1.7	0.5	0.5	0.0	1.7	1.1	0.0	0.0	1.1	0.5	0.0	0.0
G	0.8	0.8	0.4	0.4	0.8	0.4	0.4	0.4	0.7	0.8	0.4	0.0	0.0	0.0	0.0	0.0
F	0.2	0.2	1.4	1.4	0.2	0.2	0.2	1.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
P	0.0	0.2	0.1	0.1	0.1	0.4	0.7	0.1	0.0	0.2	0.8	1.0	0.7	0.8	1.0	1.0
Total	**3.2**	**2.3**	**1.9**	**1.9**	**2.8**	**1.8**	**1.8**	**1.9**	**2.4**	**1.3**	**1.2**	**1.0**	**1.8**	**1.3**	**1.0**	**1.0**
COLOUR																
VG	0.5	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.4	0.4	1.2	0.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	1.4	1.4	0.8	1.1	1.4	1.4	1.1	0.2	0.2	02	1.1	0.2	0.0	0.2	0.0	0.0
P	0.0	0.0	0.1	0.1	0.1	0.1	0.4	0.8	0.8	0.8	0.4	0.8	1.0	0.8	1.0.	1.0
Total	**2.3**	**2.3**	**2.1**	**2.0**	**2.0**	**1.9**	**1.5**	**1.0**	**1.0**	**1.0**	**1.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
FLAVOUR																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	1.2	0.8	0.8	1.2	1.2	0.8	0.8	0.8	0.4	0.8	0.4	0.0	0.4	0.8	0.0
F	1.1	0.8	1.1	1.1	1.1	0.8	1.1	1.1	1.1	1.1	1.1	0.8	0.0	1.1	1.1	0.0
P	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.4	1.0	0.2	0.1	1.0
Total	**2.3**	**2.1**	**2.0**	**2.0**	**2.3**	**2.1**	**2.0**	**2.0**	**1.9**	**1.7**	**2.0**	**1.6**	**1.0**	**1.7**	**2.0**	**1.0**
TASTE																
VG	2.8	1.7	1.7	0.5	1.7	1.7	1.1	0.0	1.1	1.7	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	1.2	0.8	1.2	0.8	1.2	0.8	0.4	0.8	0.8	0.4	0.0	0.8	0.0	0.4	0.0
F	0.0	0.2	0.5	0.2	0.2	0.2	0.2	1.4	0.2	0.2	1.4	1.4	0.5	0.5	1.4	0.0
P	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.1	0.2	0.1	0.1	0.2	0.0	0.7	0.1	1.0
Total	**3.0**	**3.1**	**2.0**	**2.1**	**2.8**	**3.1**	**2.3**	**1.9**	**2.3**	**2.8**	**1.9**	**1.8**	**1.3**	**1.2**	**1.9**	**1.0**
TEXTURE																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.8	1.2	1.7	0.4	0.4	0.8	0.8	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.8	0.8	0.8	0.2	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.2	0.2	0.0	0.0
P	0.7	0.1	0.0	0.4	0.7	0.7	0.7	1.0	0.7	0.7	1.0	1.0	0.8	0.8	1.0	1.0
Total	**1.5**	**2.1**	**2.5**	**1.6**	**1.3**	**1.5**	**1.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

VG – Very good, G – Good, F – Fair, P - Poor

4.1.2 Changes in organoleptic quality during storage

4.1.2.1 Dried pulp

Data on the effect of storage period and packaging materials on organoleptic qualities of dried pulp are presented in Table 19. The data were not subjected to statistical analysis. However the score obtained showed that there was a gradual decrease over the entire storage period in the organoleptic qualities of the products with respect to various attributes such as appearance, colour, flavour, taste and texture.

Dried pulp packed in glass bottles had the highest mean score of 3.6 for appearance at beginning of the storage period followed by T_2 (3.3), T_3 (2.3) and T_4 (2.2). It was seen that almost the same trend was maintained throughout the storage period of sixth months. T_1 maintained the score of 3.6 for appearance upto the third month and thereafter started decreasing. T_2, T_3 and T_4 score for appearance started reducing from second month onwards. At the end of the storage period of sixth months T_1 scored 1.8 followed by T_2 (1.3) and T_3 and T_4 scoring 1.0 each.

Mean score for colour revealed that T_1 had the highest score of 2.8 followed by T_2 (2.7), T_3 (2.3) and T_4 (2.2) at the beginning of the storage period which was maintained in the second month also but showed a decreasing trend thereafter. At the end of the storage period, the product packed in all the four different packaging material had the same score of 1.0.

The highest mean score obtained for flavour was for T_1 (2.8) followed by T_2 (2.7), T_3 (2.5) and T_4 (2.2). The score for flavour started reducing from second month onwards in the case of T_1 and T_2 while it remain the same upto the second month in the case of T_3 and T_4. A score of 1.0 was recorded for colour at the end of the storage period in the case of each packaging materials.

The highest mean score for taste at the beginning of the storage period was obtained by T_1 (3.8) followed by T_3 (3.6), T_2 (3.4) and T_4 (2.8). The

Table 20. Effects of storage period and packaging materials on organoleptic qualities of pulp powder (mean score obtained out of four)

	D_1				D_2				D_3			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE												
VG	2.8	2.2	3.4	0.5	2.2	2.2	2.8	0.5	2.2	2.2	2.8	0.0
G	0.8	1.2	0.4	2.1	0.8	0.8	0.8	1.7	0.4	0.4	0.4	1.2
F	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.5	0.5	0.5	0.2	1.1
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**3.6**	**3.4**	**3.8**	**2.8**	**3.2**	**3.2**	**3.6**	**2.7**	**3.1**	**3.1**	**3.4**	**2.3**
COLOUR												
VG	2.2	0.0	3.4	0.5	0.0	0.0	2.2	1.1	0.0	0.0	1.1	0.5
G	1.2	2.5	0.4	2.5	2.1	2.1	1.2	0.4	1.7	1.2	0.4	0.4
F	0.0	0.2	0.0	0.0	0.5	0.5	0.0	0.2	0.8	0.8	0.2	0.5
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.1	0.4	0.4
Total	**3.4**	**2.7**	**3.8**	**3.0**	**2.6**	**2.6**	**3.4**	**2.1**	**2.5**	**2.1**	**2.1**	**1.8**
FLAVOUR												
VG	1.7	0.5	1.1	0.5	0.0	0.5	1.1	0.5	0.0	0.0	0.0	0.0
G	0.8	1.2	1.7	0.4	0.8	1.2	0.8	0.4	0.8	0.0	0.8	0.8
F	0.2	0.8	0.0	1.4	1.1	0.0	0.5	0.5	0.0	0.2	1.4	0.0
P	0.0	0.0	0.1	0.0	0.1	0.4	0.1	0.4	0.7	0.8	0.0	0.7
Total	**2.7**	**2.5**	**2.7**	**2.3**	**2.0**	**2.1**	**2.5**	**1.8**	**1.5**	**1.0**	**2.2**	**1.5**
TASTE												
VG	2.8	0.5	1.1	0.0	2.8	0.5	1.1	0.0	1.1	0.0	0.0	0.0
G	2.8	0.8	1.7	0.8	0.8	0.8	1.7	0.8	0.8	1.2	1.7	0.4
F	0.0	0.8	0.5	0.5	0.0	0.8	0.0	0.5	0.2	0.8	0.8	0.2
P	0.0	0.1	0.0	0.4	0.0	0.1	0.1	0.4	0.2	0.1	0.0	0.5
Total	**3.6**	**2.2**	**3.3**	**1.7**	**3.6**	**2.2**	**2.9**	**1.7**	**2.3**	**2.1**	**2.5**	**1.1**
TEXTURE												
VG	3.4	3.4	2.2	2.2	2.8	2.8	1.1	1.1	2.2	1.7	1.1	0.5
G	0.4	0.4	1.2	1.2	0.8	0.8	1.7	1.7	1.2	0.8	1.7	0.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.5
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Total	**3.8**	**3.8**	**3.4**	**3.4**	**3.6**	**3.6**	**3.3**	**3.3**	**3.4**	**2.0**	**3.3**	**1.8**

VG – Very good, G – Good, F – Fair, P - Poor

Table 20. Continued

	D_4				D_5				D_6				D_7			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE																
VG	1.1	1.7	2.2	0.0	0.5	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.4	0.4	0.4	0.0	0.4	1.7	0.4	0.0	0.0	1.2	0.4	0.0	0.0	0.8	0.0	0.0
F	0.2	0.8	0.5	1.4	0.5	0.8	0.2	1.1	0.5	0.8	0.8	0.8	0.0	0.8	.05	0.0
P	0.4	0.0	0.0	0.2	0.4	0.0	0.4	0.4	0.7	0.1	0.4	0.5	1.0	0.2	0.7	1.0
Total	**2.1**	**2.9**	**3.1**	**1.6**	**1.8**	**2.3**	**2.1**	**1.4**	**1.2**	**2.1**	**1.6**	**1.3**	**1.0**	**1.8**	**1.2**	**1.0**
COLOUR																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	1.2	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.8	0.5	0.5	0.5	0.5	1.4	1.1	0.0	0.5	1.1	0.8	0.0	0.5	0.5	0.8	0.0
P	0.1	0.2	0.4	0.7	0.4	0.2	0.4	1.0	0.7	0.4	0.5	1.0	0.7	0.7	0.5	1.0
Total	**2.2**	**1.9**	**1.7**	**1.3**	**1.7**	**1.6**	**1.4**	**1.0**	**1.3**	**1.5**	**1.3**	**1.0**	**1.2**	**1.2**	**1.3**	**1.0**
FLAVOUR																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.2	0.2	0.8	0.8	0.8	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P	0.5	0.8	0.5	0.5	0.5	1.0	0.8	0.8	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	**1.5**	**1.0**	**1.3**	**1.3**	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
TASTE																
VG	1.7	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0
G	0.8	0.8	1.7	0.4	0.8	0.8	0.8	0.0	0.4	0.4	0.0	0.0	0.4	0.0	0.00	0.0
F	0.5	1.1	0.8	0.2	0.5	1.1	0.0	0.2	1.4	0.8	0.0	0.2	1.4	0.0	.0.00	0.0
P	0.0	0.1	0.0	0.5	0.0	0.1	0.7	0.8	0.1	0.4	1.0	0.8	0.1	1.0	1.0	1.0
Total	**2.0**	**2.0**	**2.5**	**1.1**	**2.0**	**2.0**	**1.5**	**1.0**	**1.9**	**1.6**	**1.0**	**1.0**	**1.9**	**1.0**	**1.0**	**1.0**
TEXTURE																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.0	0.8	1.2	0.8	0.0	0.0	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
F	0.8	0.0	0.8	0.0	0.8	0.8	0.0	0.8	0.8	0.8	0.0	0.8	0.0	0.8	0.8	0.0
P	0.5	0.7	0.1	0.7	0.2	0.5	0.7	0.5	0.2	0.5	0.7	0.2	1.0	0.2	0.5	1.0
Total	**1.3**	**1.5**	**2.1**	**1.5**	**1.0**	**1.3**	**1.5**	**1.3**	**1.0**	**1.3**	**1.5**	**1.0**	**1.0**	**1.0**	**1.3**	**1.0**

VG – Very good, G – Good, F – Fair, P - Poor

score remained the same in the case of T_1 and T_2 in the second month also while that in the case of T_3 and T_4 started decreasing from second month onwards. At the end of the sixth months storage period, the highest score for taste was obtained by T_3 (1.9) followed by T_1 (1.3), T_2 (1.2) and T_4 (1.0).

The highest mean score for texture in the beginning of the storage period was obtained by T_3 (2.9) followed by T_1 and T_2 (2.7) and T_4 (2.3). T_3 maintained the same score in the second month also thereafter showing an decreasing trend. T_1, T_2 and T_4 showed decreasing trend from the second month onwards. From the sixth months till the end of the storage period score for texture with respect to all the four packaging materials was 1.0.

4.1.2.2 Pulp powder

Data on the effect of storage period and packaging materials on organoleptic qualities of pulp powder are presented in Table 20. The data were not subjected to statistical analysis. It was seen from the data that the highest mean score for appearance at the beginning of the storage period was obtained by T_3 (3.8) followed by T_1 (3.6) and T_2 (3.4) and T_4 (2.8). It was also seen that the score for appearance gradually decrease with the advancement of storage period recording the highest mean score at the end of the storage period as 1.8 (T_2) followed by 1.2 (T_3) and 1.0 (T_1 and T_4).

The highest mean score for colour at the beginning of the storage period was recorded as 3.8 (T_3) followed by 3.4 (T_1), 3.0 (T_4) and 2.7 (T_2). Score for colour was also found to decrease with the progressing storage period with the highest mean score at the end of the storage period found in T_3 (1.3) followed by T_1 and T_2 (1.2) and T_4 (1.0).

The highest mean score for flavour at the beginning of the storage period was shared by T_1 and T_3 (2.7) followed by T_2 (2.5) and T_4 (2.3). Score for flavour reduced drastically and reached the lowest mean score of 1.0 with respect to all the packaging materials even at the beginning of fifth month of storage except that for glass bottles where the score was 1.3 from

Table 21. Effects of storage period and packaging materials on organoleptic qualities of dried pieces of fruits (mean score obtained out of four)

	D_1				D_2				D_3			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE												
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	1.7	1.4	2.0	1.1	1.4	1.1	1.7	0.8	1.1	1.1	1.4	0.5
P	0.1	0.2	0.0	0.4	0.2	0.4	0.1	0.5	0.4	0.4	0.2	0.7
Total	**1.8**	**1.6**	**2.0**	**1.5**	**1.6**	**1.5**	**1.8**	**1.3**	**1.5**	**1.5**	**1.6**	**1.2**
COLOUR												
VG	1.1	1.1	0.5	0.0	1.1	1.1	0.5	0.0	0.5	0.5	0.0	0.0
G	0.8	1.2	1.2	1.2	0.8	1.2	0.8	0.8	0.8	1.2	1.2	0.0
F	0.8	0.5	0.8	1.1	0.8	0.5	0.8	0.8	0.8	0.8	1.1	0.8
P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total	**2.7**	**2.8**	**2.5**	**2.3**	**2.7**	**2.8**	**2.1**	**2.1**	**2.1**	**2.5**	**2.3**	**1.3**
FLAVOUR												
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	1.7	0.8	0.8	1.2	0.0	0.8	0.8	0.0	0.0	0.8	0.0
F	1.1	0.8	1.1	0.8	1.1	1.4	1.1	0.5	1.7	1.4	0.5	0.8
P	0.0	0.0	0.1	0.2	0.0	0.2	0.1	0.4	0.1	0.2	0.4	0.5
Total	**2.3**	**2.5**	**2.0**	**1.8**	**2.3**	**1.6**	**2.0**	**1.7**	**1.8**	**1.6**	**1.7**	**1.3**
TASTE												
VG	2.8	1.1	0.5	0.0	2.2	1.1	0.5	0.0	2.2	1.1	0.5	0.0
G	0.8	1.7	0.8	0.5	0.8	1.2	0.8	0.5	0.8	0.8	0.4	0.8
F	0.0	0.5	0.8	1.4	0.2	0.5	0.8	1.4	0.2	0.2	0.2	0.5
P	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.7	0.4
Total	**3.6**	**3.3**	**2.2**	**1.9**	**3.2**	**2.8**	**2.2**	**1.9**	**3.2**	**2.3**	**1.8**	**1.7**
TEXTURE												
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	2.1	1.7	0.0	0.0	1.7	1.7	0.0	0.0	1.2	1.2	0.0	0.0
F	0.5	0.8	1.4	0.5	0.8	0.8	1.1	0.5	0.8	0.5	0.8	0.2
P	0.0	0.0	0.2	0.7	0.0	0.0	0.4	0.7	0.1	0.2	0.5	0.8
Total	**2.6**	**2.5**	**1.6**	**1.2**	**2.5**	**2.5**	**1.5**	**1.2**	**2.1**	**1.9**	**1.3**	**1.0**

VG – Very good, G – Good, F – Fair, P - Poor

Table 21. Continued

	D_4				D_5				D_6				D_7			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
APPEARANCE																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.8	0.8	1.1	0.2	0.2	0.8	0.8	0.0	0.2	0.0	0.2	0.2	0.0	0.2	0.2	0.0
P	0.5	0.5	0.4	0.8	0.8	0.5	0.5	1.0	0.8	1.0	0.8	0.8	1.0	0.5	0.8	1.0
Total	**1.3**	**1.3**	**1.5**	**1.0**	**1.0**	**1.3**	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
COLOUR																
VG	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.8	0.8	1.7	0.8	1.7	0.8	0.8	0.2	0.8	0.2	0.0	0.0	0.8	0.0	0.2	0.0
P	0.0	0.0	0.1	0.5	0.1	0.5	0.5	0.8	0.5	0.8	1.0	1.0	0.5	1.0	0.8	1.0
Total	**2.1**	**2.1**	**1.8**	**1.3**	**1.8**	**1.3**	**1.3**	**1.0**	**1.3**	**1.0**	**1.0**	**1.0**	**1.3**	**1.0**	**1.0**	**1.0**
FLAVOUR																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.8	1.1	0.8	0.8	0.2	0.8	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
P	0.5	0.4	0.5	0.5	0.8	0.5	0.8	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Total	**1.3**	**1.5**	**1.3**	**1.3**	**1.0**	**1.3**	**1.0**	**1.0**	**1.0**	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
TASTE																
VG	2.8	1.1	0.0	0.0	1.7	1.1	0.5	0.0	1.1	1.1	0.0	0.0	1.1	0.5	0.0	0.0
G	1.2	0.8	0.4	0.0	0.8	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.0	0.2	1.4	0.8	0.2	0.2	0.2	0.8	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0
P	0.0	0.2	0.1	0.5	0.1	0.2	0.7	0.5	0.7	0.7	0.8	0.8	0.7	08	1.0	1.0
Total	**3.0**	**2.3**	**1.9**	**1.3**	**2.8**	**2.3**	**1.8**	**1.3**	**1.8**	**1.8**	**1.0**	**1.0**	**1.8**	**1.3**	**1.0**	**1.0**
TEXTURE																
VG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	1.2	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.5	0.5	0.2	0.2	0.8	0.5	0.0	0.0	0.2	0.8	0.0	0.0	0.0	0.2	0.0	0.0
P	0.2	0.2	0.8	0.8	0.5	0.2	1.0	1.0	0.8	0.5	1.0	1.0	1.0	0.8	1.0	1.0
Total	**1.9**	**1.9**	**1.0**	**1.0**	**1.3**	**1.9**	**1.0**	**1.0**	**1.0**	**1.3**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

VG – Very good, G – Good, F – Fair, P - Poor

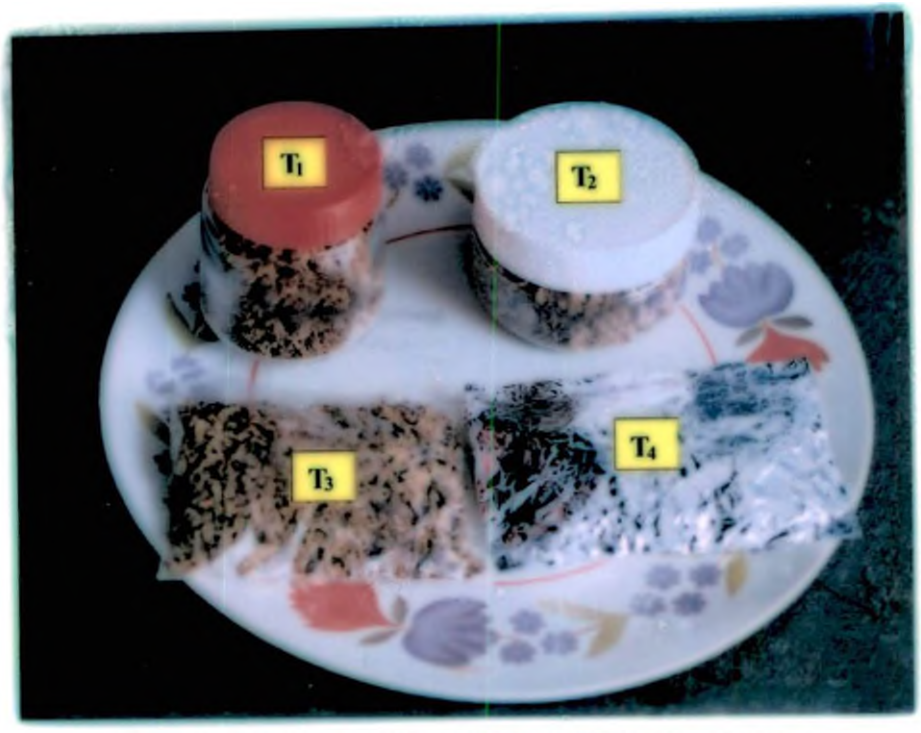

Plate 6. Dried pulp of drumstick in different packages

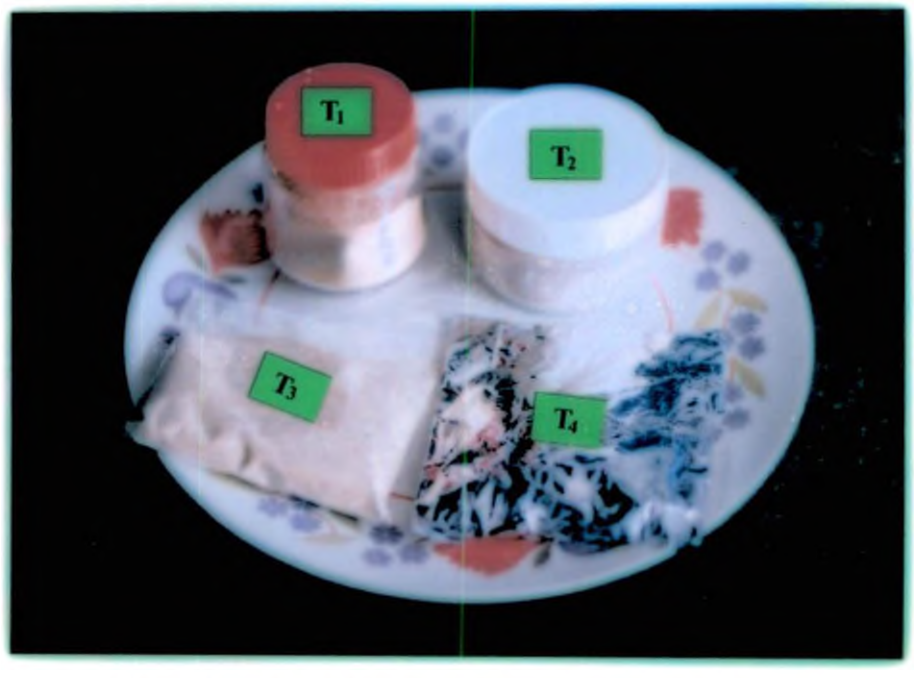

Plate 7. Pulp powder of drumstick in different packages

the beginning of the sixth months till the end of the storage period the score remained 1.0 for all.

The highest mean score for taste at the beginning of storage period was found with T_1 (3.6) followed by T_3 (3.3), T_2 (2.2) and T_4 (1.7). T_1 and T_2 maintained the same score at the beginning of second month also except that the score for taste reduced progressively with advancement of the storage period with scores recorded at the end of the storage period as 1.9 (T_1) and 1.0 each for T_2, T_3 and T_4.

With regard to the texture of pulp powder the highest mean score of 3.8 was recorded with both T_1 and T_2 followed by 3.4 each for T_3 and T_4. It was found that score for texture progressively decrease over the storage period reaching a score of 1.3 for T_3 and 1.0 each for T_1, T_2 and T_4 at the end of the storage period.

4.1.2.3 Dried fruit pieces

Data on the effect of storage period and packaging materials on organoleptic qualities of dried fruit pieces are presented in Table 21. The data were not subjected to statistical analysis. At the beginning of the storage period, the highest mean score for appearance was found to be 2.0 (T_3) followed by 1.8 (T_1), 1.6 (T_2) and 1.5 (T_4). There was gradual decrease in the score for appearance as revealed by monthly evaluation. The lowest score of 1.0 was found with T_4 at the end of the fourth month itself while T_1, T_2 and T_3 following suit at the beginning of the sixth months and score remained 1.0 each for all the four treatment at the end of the storage period.

The highest mean score obtained for colour was for T_2 (2.8) followed by T_1 (2.7), T_3 (2.5) and T_4 (2.3). T_2 and T_1 maintained the same score at the beginning of second month also. Score for colour gradually decrease as the storage period advanced recording a score of 1.3 for T_1 and 1.0 each for T_2, T_3 and T_4 at the beginning of the sixth months. A score for each remained the same at the end of the storage period also.

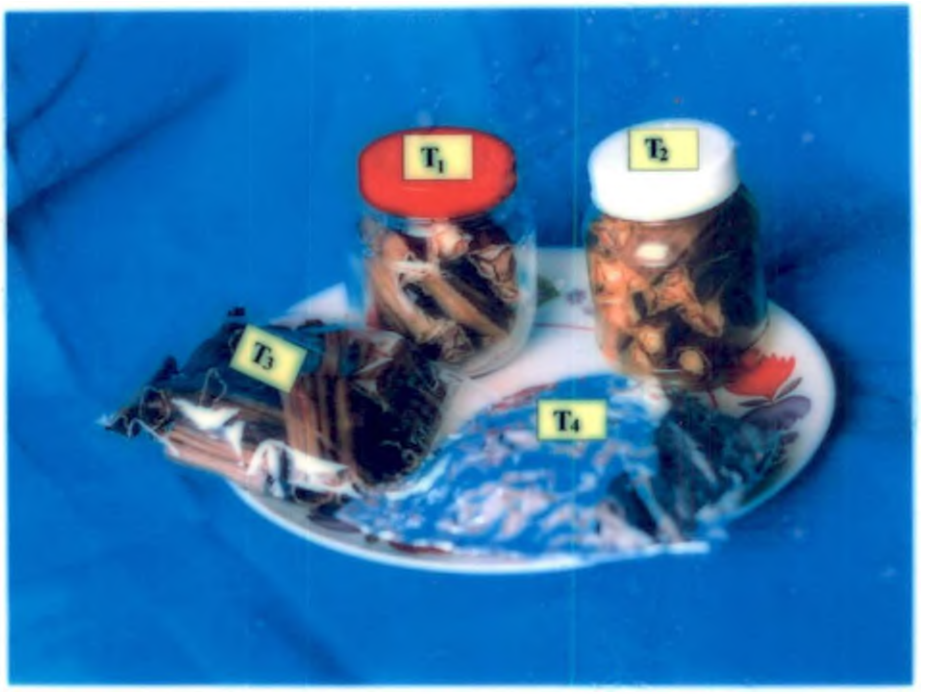

Plate 8. Dried fruit pieces of drumstick in different packages

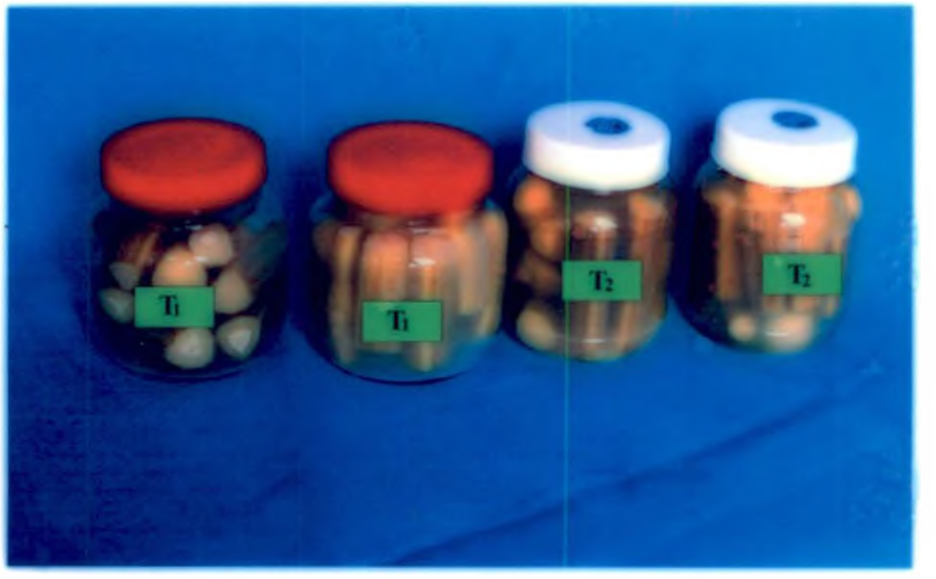

Plate 9. Bottled fruit pieces of drumstick in brine

Table 22. Organoleptic evaluation of reconstituted dried products (mean score obtained out of four)

Criteria	Score	P_1	P_2	P_3
APPEARANCE				
VG	4	2.4	2.1	2.8
G	3	1.2	1.2	0.9
F	2	0.0	0.0	0.0
P	1	0.0	0.0	0.0
Total		**3.6**	**3.3**	**3.7**
COLOUR				
VG	4	0.8	1.2	0.4
G	3	2.4	1.5	2.1
F	2	0.0	0.4	0.4
P	1	0.0	0.0	0.0
Total		**3.2**	**3.1**	**2.9**
FLAVOUR				
VG	4	0.4	2.4	0.4
G	3	1.8	0.4	1.2
F	2	0.6	0.0	1.0
P	1	0.0	0.0	0.0
Total		**2.8**	**2.8**	**2.6**
TASTE				
VG	4	0.0	2.1	0.4
G	3	2.4	0.6	1.8
F	2	0.4	0.0	0.6
P	1	0.0	0.0	0.0
Total		**2.8**	**2.7**	**2.8**
TEXTURE				
VG	4	0.8	1.2	2.0
G	3	2.4	1.5	1.5
F	2	0.0	0.4	0.0
P	1	0.0	0.0	0.0
Total		**3.2**	**3.1**	**3.5**

VG – Very good, G – Good, F – Fair, P - Poor

The highest mean score for flavour was found with T_2 (2.5) followed by T_1 (2.3), T_3 (2.0) and T_4 (1.8). It was found that the scores gradually decrease over the storage period to 1.3 (T_2) and 1.0 each (T_1, T_3 and T_4) at the beginning of the fifth month which remained the same at the beginning of the sixth month also. At the end of the storage period each had a score of 1.0.

Taste was also found decreasing gradually over the storage period from the highest mean value at the beginning of the storage period obtained for T_1 (3.6) followed by T_2 (3.3), T_3 (2.2) and T_4 (1.9) to 1.8 (T_1), 1.3 (T_2) and 1.0 each for T_3 and T_4 at the end of the storage period.

The highest mean score for texture at the beginning of the storage period was recorded with T_1 (2.6) followed by T_2 (2.5), T_3 (1.6) and T_4 (1.2). Score for texture was found decreasing gradually as the storage period increase recording a score of 1.0 each for all the four treatments at the end of the storage period.

4.1.2.4 Reconstituted dried products

Data on organoleptic evaluation of reconstituted dried products are presented in Table 22. Data were not subjected to statistical analysis. When the dried products were subjected to organoleptic evaluation, the highest mean score for appearance was scored by P_3 (3.7) followed by P_1 (3.6) and P_2 (3.3). With respect to colour P_1 obtained the highest mean score of 3.2 followed by P_2 (3.1) and P_3 (2.9). Both P_1 and P_2 scored the highest mean score of 2.8 each with respect to flavour followed by P_3 (2.6). The highest mean score of 2.8 for taste was shared by P_1 and P_3 followed by 2.7 for P_2. P_3 obtained the highest mean score of 3.5 followed by P_1 (3.2) and P_2 (3.1) with respect to texture.

A

B

Plate 10. Reconstitution of dried products of drumstick

A. Before reconstitution

B. After reconstitution

Table 23. Effect of packaging materials and storage period on ascorbic acid content (mg/100 g) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	4.20	4.16	4.18
D_2	3.77	3.79	3.78
D_3	3.67	3.65	3.66
D_4	3.47	3.45	3.46
D_5	2.79	1.95	2.37
CD (5.%) D – 0.069 T x D – 0.098			

Table 24. Effect of packaging materials and storage period on fibre content (g/100 g) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	3.67	3.63	3.65
D_2	3.67	3.63	3.65
D_3	3.67	3.61	3.64
D_4	3.65	3.61	3.63
D_5	3.65	3.60	3.63
CD (5 %) D – 0.027 T x D – 0.038			

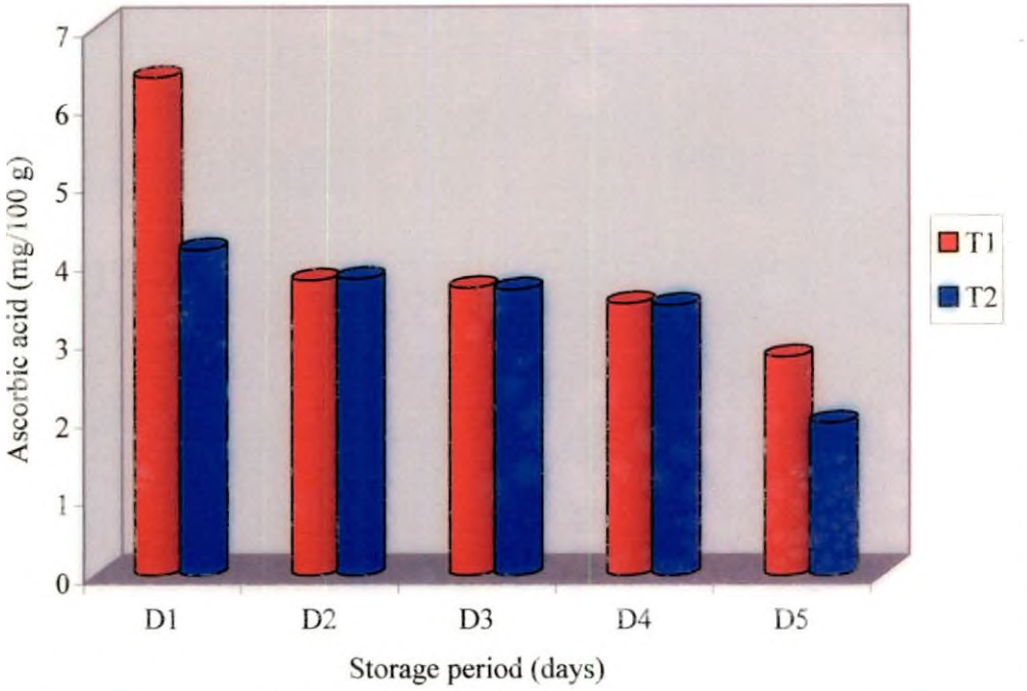

Fig. 7. Effect of packaging materials and storage period on ascorbic acid (mg/100 g) content in bottled fruit pieces in brine

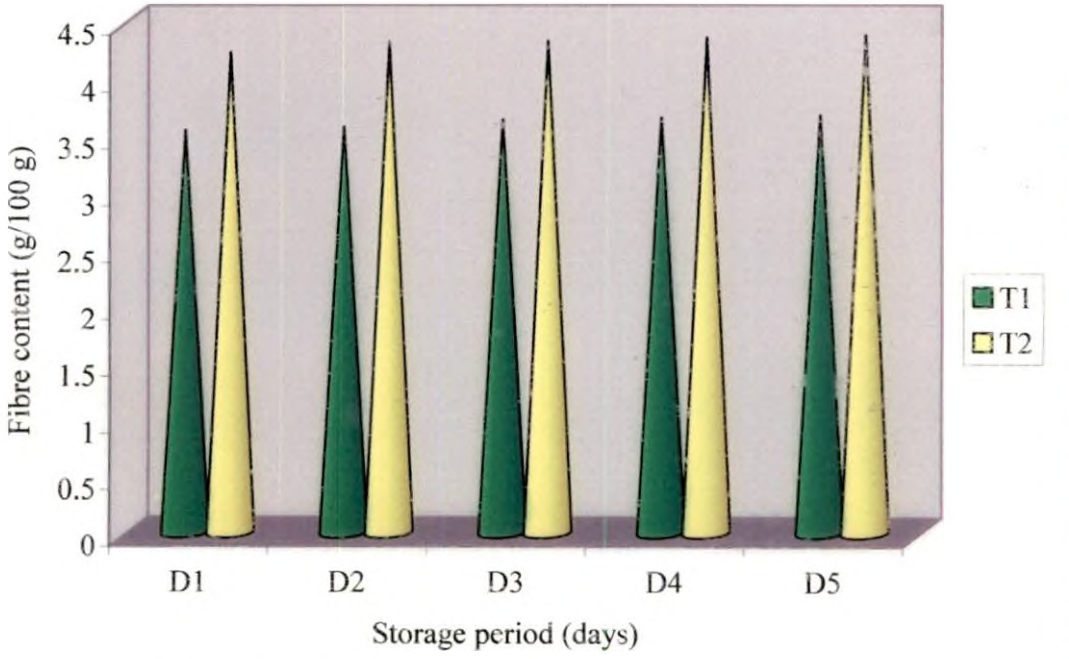

Fig. 8. Effect of packaging materials and storage period on fibre content (g/100 g) in bottled fruit pieces in brine

4.2 BOTTLED FRUIT PIECES IN BRINE

4.2.1 Changes in biochemical qualities during storage

4.2.1.1 Ascorbic acid

Data on effect of packaging materials and storage period on ascorbic acid content of bottled fruit pieces in brine are presented in Table 23. The product was found unfit for consumption due to microbial spoilage after four months of storage. The mean ascorbic acid content of bottled fruit pieces in brine packed in two different packaging materials showed that the values decreased significantly every month from 4.18 mg/100 g at the beginning of the storage period to 2.37 mg/100 g at the end of the storage period. Among the two packaging materials, T_1 had the highest ascorbic acid content of 4.20 mg/100 g at the beginning of the storage period. It was found to reduce significantly every month to 2.79 mg/100 g at the end of the storage period. T_2 also showed a similar trend of significant monthly reduction from 4.16 mg/100 g to 1.95 mg/100 g.

4.2.1.2 Fibre

Data on effect of packaging materials and storage period on fibre content of bottled fruit pieces in brine are given in Table 24. The data revealed that there was no significant change in fibre content of bottled fruit pieces in brine during the entire storage period of four months after which the product was discarded due to microbial spoilage. It also showed that there was no significant difference in fibre content of the product packed in different packaging materials.

4.2.1.3 Fat

Data on effect of packaging materials and storage period on fat content of bottled fruit pieces in brine are presented in Table 25. The product were stored and were evaluated at monthly interval for four months after which it had to be discarded due to microbial spoilage. The mean values showed that there was no significant monthly changes in the fat

Table 25. Effect of packaging materials and storage period on fat content (g/100 g) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	0.082	0.086	0.084
D_2	0.078	0.085	0.082
D_3	0.078	0.081	0.080
D_4	0.072	0.076	0.074
D_5	0.070	0.072	0.071
CD (5 %) D – 0.0038 T x D – 0.0056			

Table 26. Effect of packaging materials and storage period on protein content (g/100 g) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	1.48	1.49	1.49
D_2	1.38	1.40	1.39
D_3	1.38	1.40	1.39
D_4	1.38	1.04	1.21
D_5	1.07	1.03	1.05
CD (5 %) D – 0.070 T x D – 0.110			

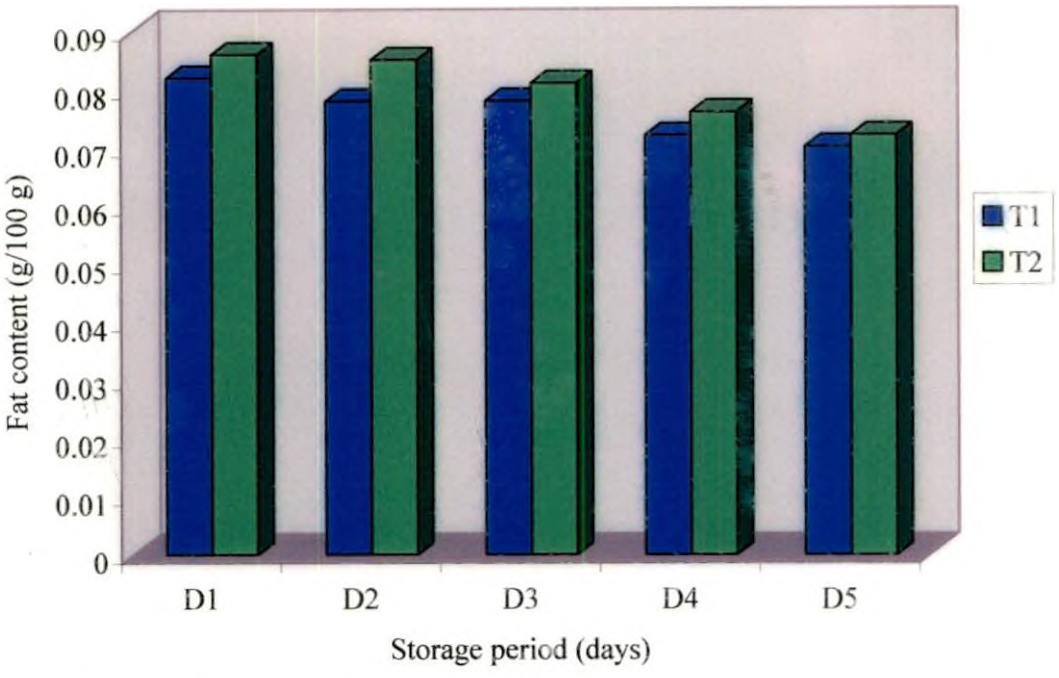

Fig. 9. Effect of packaging materials and storage period on fat content (g/100 g) in bottled fruit pieces in brine

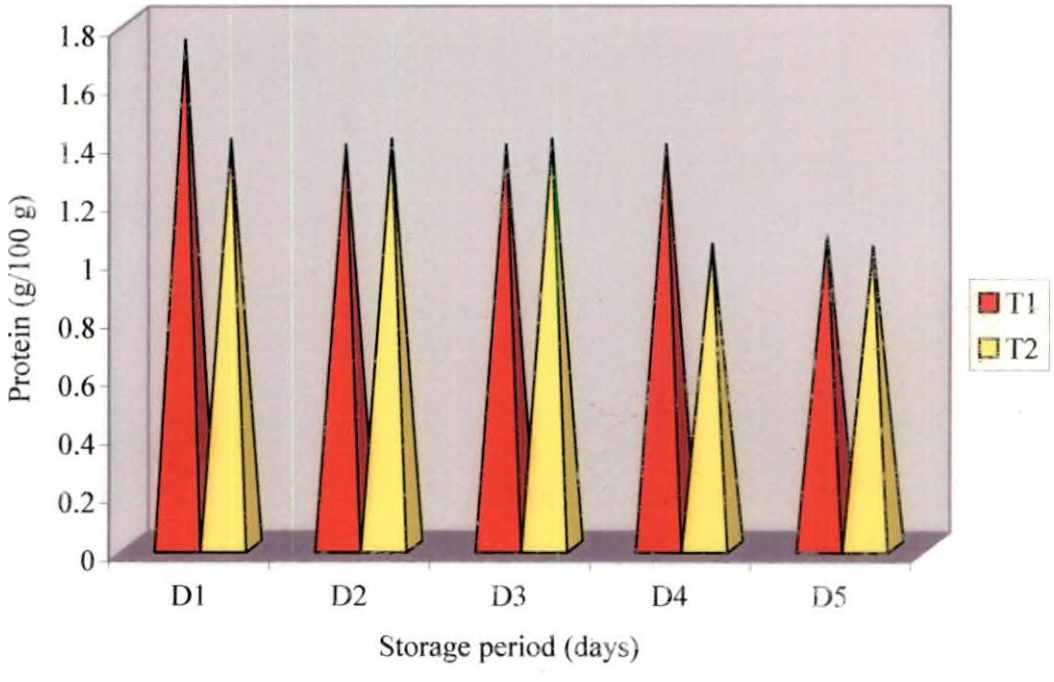

Fig. 10. Effect of packaging materials and storage period on protein (g/100 g) in bottled fruit pieces in brine

content except at the beginning of fourth month of storage. The mean fat content of 0.084 g/100g at the beginning of the storage significantly reduced to 0.071 g/100 g at the end of the storage period. Bottled fruit pieces in brine packed in glass bottles (T_1) showed an initial fat content of 0.082 g/100 g which reduced significantly to 0.072 g/100 g at the fourth month and then to 0.070 g/100 g at the end of the fourth months of storage. Fruit pieces packed in PET bottles showed an initial fat content of 0.086 g/100 g which significantly reduce to 0.072 g/100 g though the monthly changes were not significant.

4.2.1.4 Protein

Data on effect of packaging materials and storage period on protein content of bottled fruit pieces in brine are presented in Table 26. The product had a storage life of only four months due to microbial spoilage noticed after four months of storage. The mean value of protein content of 1.49 g/100 g at the beginning of the storage period was found to decrease significantly every month giving a mean value of 1.05 g/100 g at the end of the storage period. Fruit pieces in brine packed in glass bottles showed an initial protein content of 1.48 g/100 g which showed significant reduction at the end of the storage period where the value was 1.07 g/100 g. Fruit pieces in brine packed in PET bottles showed an initial value of 1.49 g/100 g and thereafter significant change was noted in the fourth month and the value at the end of the storage period reduce to 1.03 g/100 g. Significant differences in values between the two packaging materials were noted only in the fourth month of storage.

4.2.1.5 Vitamin A

Data on the effect of packaging materials and storage period on vitamin A content of bottled fruit pieces in brine are presented in Table 27. It was seen from the mean values of vitamin A content reduced significantly every month from an initial value of 139.84 IU to 138.33 IU at the end of the storage period. Fruits packed in glass bottles (T_1) had an initial vitamin A

Table 27. Effect of packaging materials and storage period on vitamin A content (IU) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	139.94	139.73	139.84
D_2	139.21	139.35	139.28
D_3	138.93	139.01	138.97
D_4	138.69	138.73	138.71
D_5	138.22	138.43	138.33
CD (5 %) D – 0.22		T x D – 0.30	

Table 28. Effect of packaging materials and storage period on total carbohydrate content (g/100 g) of bottled fruit pieces in brine

Days	T_1	T_2	Mean
D_1	3.53	3.33	3.43
D_2	2.83	3.03	2.93
D_3	2.73	2.50	2.62
D_4	2.57	2.13	2.35
D_5	2.33	1.83	2.08
CD (5 %) D – 0.07		T x D – 0.11	

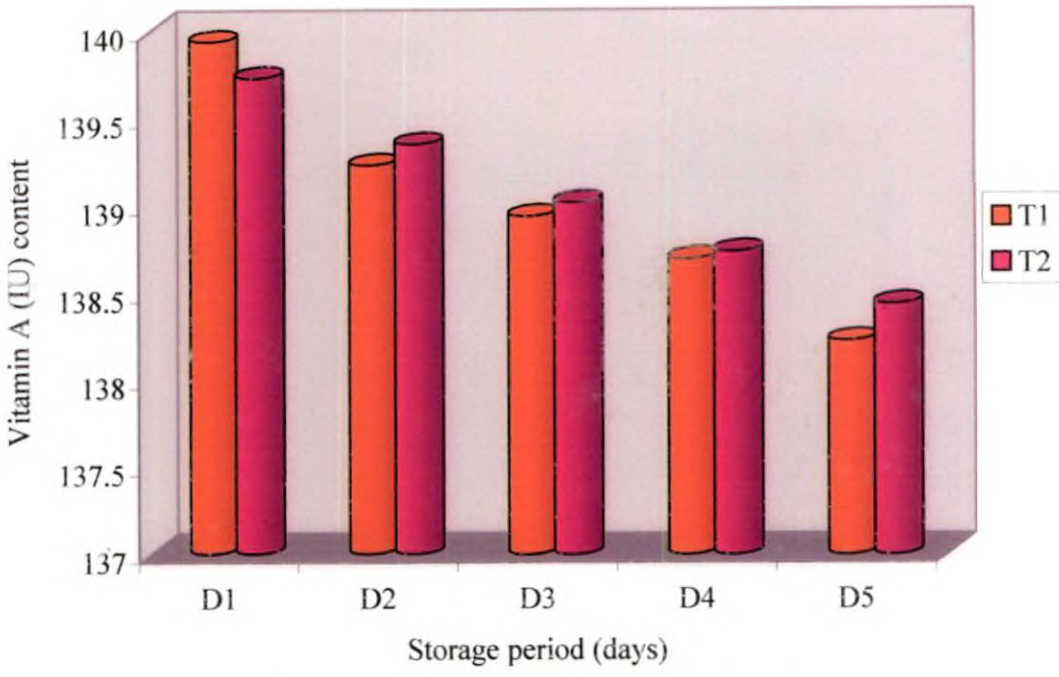

Fig. 11. Effect of packaging materials and storage period on vitamin A (IU) content of bottled fruit pieces in brine

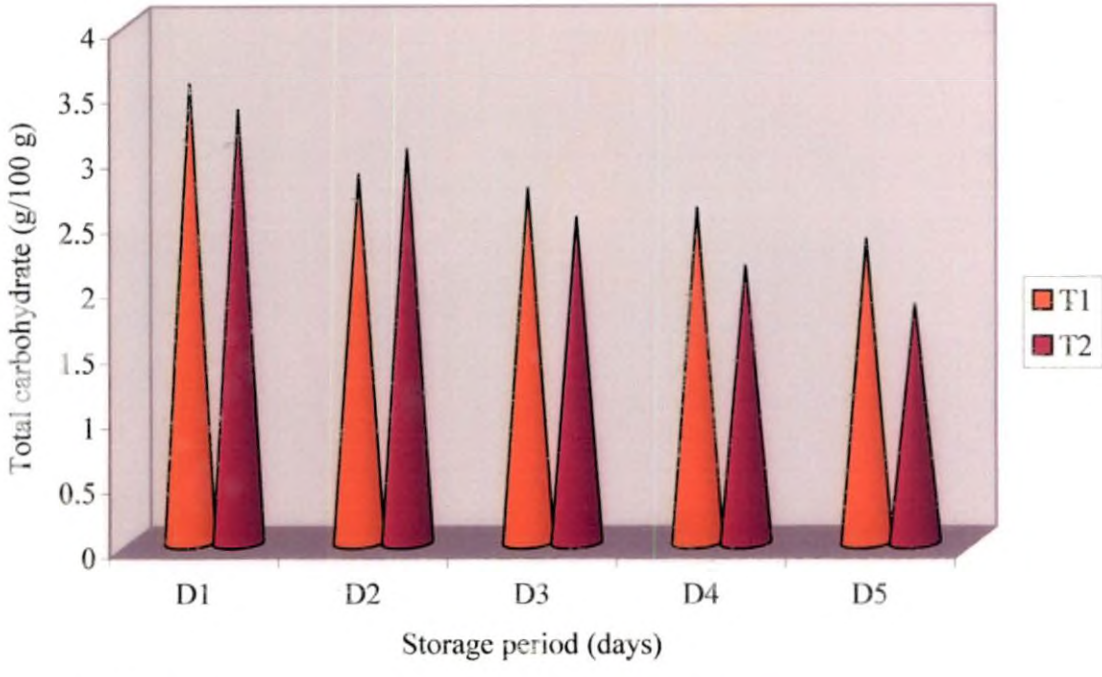

Fig. 12. Effect of packaging materials and storage period on total carbohydrate (g/100 g) content in bottled fruit pieces in brine

content of 139.94 IU which reduced significantly every month except in the fourth month to 138.22 IU at the end of the storage period. Fruits packed in PET bottles had a vitamin A content of 139.73 IU at the beginning of the storage period which reduced to 138.43 IU at the end of the storage period with significant reduction noted in the second and third months. The storage period was limited to four months due to microbial spoilage.

4.2.1.6 Total carbohydrate

Data on effect of packaging materials and storage period on total carbohydrate content of bottled fruit pieces in brine are presented in Table 28. The product stored well for a period of four months and thereafter were discarded due to microbial spoilage. The mean values of total carbohydrate content revealed that there was significant reduction every month from 3.43 g/100 g at the beginning of the storage period to 2.08 g/100 g at the end of the storage period. Fruits packed in glass bottles (T_1) recorded initial total carbohydrate content of 3.53 g/100 g which reduced significantly every month except in the third month to 2.33 g/100 g at the end of the storage period. Fruits packed in PET bottles showed an initial total carbohydrate content of 3.33 g/100 g and 1.83 g/100 g at the end of the storage period showing significant reduction every month.

4.2.2 Change in organoleptic quality during storage

4.2.2.1 Bottled fruit pieces in brine

Data on the effect of storage period and packaging materials on organoleptic qualities of bottled fruit pieces in brine are presented in Table 29. The product could only be stored for four months after which it had to be discarded due to microbial spoilage.

The highest mean score for appearance at the beginning of the storage period was obtained by T_1 (2.8) followed by T_2 (2.2). The score reduced gradually over the storage period reaching a score of 1.0 each for T_1 and T_2 at the end of the storage period. A similar trend was also observed with

Table 29. Effects of storage period and packaging materials on organoleptic qualities of bottled fruit pieces in brine (mean score obtained out of four)

	D_1		D_2		D_3		D_4		D_5	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
APPEARANCE										
VG	1.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.2	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.5	1.4	1.1	1.4	1.4	1.1	1.1	0.8	0.0	0.0
P	0.0	0.0	0.0	0.2	0.2	0.4	0.4	0.5	1.0	1.0
Total	**2.8**	**2.2**	**2.4**	**1.6**	**1.6**	**1.6**	**1.5**	**1.3**	**1.0**	**1.0**
COLOUR										
VG	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	2.1	0.4	0.8	0.4	0.4	0.4	0.0	0.0	0.0	0.0
F	0.2	1.7	1.4	1.7	1.7	1.7	0.0	0.0	0.0	0.0
P	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
Total	**2.8**	**2.1**	**2.2**	**2.1**	**2.1**	**2.1**	**1.0**	**1.0**	**1.0**	**1.0**
FLAVOUR										
VG	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	2.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	0.2	0.8	1.7	1.4	1.7	1.4	0.0	0.0	0.0	0.0
P	0.0	0.1	0.1	0.2	0.1	0.2	1.0	1.0	1.0	1.0
Total	**2.7**	**2.2**	**1.8**	**1.6**	**1.8**	**1.6**	**1.0**	**1.0**	**1.0**	**1.0**
TASTE										
VG	3.4	2.2	2.8	0.5	0.0	0.5	0.0	0.0	0.0	0.0
G	0.4	1.2	1.2	0.8	0.0	0.8	0.0	0.0	0.0	0.0
F	0.0	0.0	0.0	0.8	1.4	0.5	0.0	0.0	0.0	0.0
P	0.0	0.0	0.0	0.1	0.2	0.2	1.0	1.0	1.0	1.0
Total	**3.8**	**3.4**	**3.0**	**2.2**	**1.6**	**2.0**	**1.0**	**1.0**	**1.0**	**1.0**
TEXTURE										
VG	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G	1.7	0.4	1.2	0.4	0.0	0.4	0.0	0.0	0.0	0.0
F	0.2	1.4	0.2	1.4	1.4	1.4	0.8	0.8	0.0	0.0
P	0.1	0.1	0.4	0.1	0.2	0.1	0.5	0.5	1.0	1.0
Total	**2.5**	**1.9**	**1.8**	**1.9**	**1.6**	**1.9**	**1.3**	**1.3**	**1.0**	**1.0**

VG – Very good, G – Good, F – Fair, P - Poor

respect to the mean score for colour. The scores were 2.8 for T_1 and 2.1 for T_2 at the beginning of the storage period which reduce to 1.0 each at the beginning of fourth month which remained same at the end of the storage period also. With respect to flavour highest mean score of 2.7 was obtained by T_1 followed by (2.2) at the beginning of the storage period. These scores reduce to 1.0 each at the beginning of the fourth month and remained same at the end of the storage period. Taste also showed a similar trend recording highest mean score of 3.8 for T_1 and 3.4 for T_2 at the beginning of storage period and decrease into 1.0 each at the end of the storage period. T_1 had a score of 2.5 and T_2 had 1.9 at the beginning of storage period with respect to texture. These scores reduce gradually with respect to texture. These scores reduce gradually to 1.0 each at the end of the storage period.

Discussion

5. DISCUSSION

Results of the present investigation on product development in drumstick (*Moringa oleifera* Lam.) are discussed below and are presented under the following headings.

5.1 Dried products

5.1.1 Assessment of changes in biochemical qualities during storage

5.1.2 Assessment of organoleptic qualities during storage

5.2 Bottled fruit pieces in brine

5.2.1 Assessment of changes in biochemical qualities during storage

5.2.2 Assessment of organoleptic qualities during storage

5.1 DRIED PRODUCTS

5.1.1 Assessment of changes in biochemical qualities during storage

Results on the changes in the biochemical constituents *viz.*, ascorbic acid, fibre, fat, protein, vitamin A and total carbohydrate during storage are discussed here.

5.1.1.1 Ascorbic acid

Ascorbic acid content varied with the type of dried products made and storage period. Significant reduction was observed in ascorbic acid content of the three dried products *viz.*, dried pulp, pulp powder and dried pieces of fruits under different periods of storage. Decrease in ascorbic acid content during storage was in agreement with the findings of Oommen (1995) in osmotically dehydrated jackfruit. Significant reduction in ascorbic acid content over the entire period of storage may be due to oxidation and non-enzymatic browning. This was further substantiated by the results obtained by Lal *et al.* (2004) in dehydrated slices of Kachari (*Cucumis callosus*). According to them the ascorbic acid content of

Kachari slices was reduced with the advancement of storage because ascorbic acid is very sensitive to oxidation. This was also supported by the findings of Gupta (2006). According to him, the vitamin C potency will decrease on storage of the dry foods. The highest ascorbic acid content was found at the beginning of the storage period and lowest was found at the end of the storage period. This was also in conformity with the findings of Dasgupta *et al.* (2006). According to them ascorbic acid content of aonla shreds decreased significantly during storage period.

The ascorbic acid content was significantly higher in all the three dried products packed in T_1 (glass bottles) than T_2 (PET bottles), T_3 (polyethylene bags) and T_4 (Aluminium foil pouches) during the entire period of storage which again can be attributed to maintenance of lower moisture content and thereby less degradation of ascorbic acid.

Ascorbic acid content of fresh drumstick fruits were reported to be 120 mg/ 100 g whereas ascorbic acid content of dehydrated products were found to be lesser. This may be because of loss of ascorbic acid during washing, cutting, scrapping and dehydration. This was supported by the findings of Rai *et al.* (2004). According to them shredded cabbage and sliced cucumber reduce its ascorbic acid content by 20 per cent and 22 per cent respectively. It was further substantiated by the findings of Bineesh *et al.* (2005). They studied the degradation of ascorbic acid content in different types of cooking in drumstick leaves.

5.1.1.2 Fibre

Fibre content varied with the type of dried products made but was not influenced by storage period. No significant reduction was observed in fibre content of all the three dried products during the entire period of storage. This result was substantiated by the findings of Randhawa and Ranote (2004). According to them storage period had no profound effect on fibre content of mushroom powder. The fibre content in all the three dried products decreased very slightly during six months of storage period. The decrease in fibre content

though insignificant, may be due to the degradation of hemicellulose and other structural polysaccharide materials during storage. Similar findings have been reported by Sharon and Usha (2006) in dried breadfruit powder According to them fibre content of the dried breadfruit flour decreased during storage period. Dried pieces of fruits had found to contain more fibre as compared to dried pulp and pulp powder.

The fresh value of fibre content of drumstick fruits were reported to be 4.8 g/100 g whereas the fibre content of the dehydrated products were found to be much higher. Similar findings were reported by Lakshmi and Radha Priya (2004) in dehydrated drumstick flowers which had a high amount of fibre as compared to fresh sample.

5.1.1.3 Fat

Fat content differed significantly among the three dried products made and was also influenced by storage period. The fat content in all the three dried products packed in four packaging materials decreased significantly over the storage period. The decrease in fat content may be because of oxidation during storage period. These findings are found to be in agreement with the results obtained by Singh *et al.* (2000), who reported that fat content of the dehydrated products were significantly lost by absorption of moisture and development of rancidity due to oxidation. Gupta (2006) also reported that oxidative rancidity is accelerated by heat, metallic ions and light and lipid oxidation can occur even at very low moisture content. Similar findings were reported by Randhawa and Ranote (2004) in mushroom powder. According to them fat content in mushroom powder decreased slightly during storage period. Dried pieces of fruits were found to have more fat content as compared to dried pulp and pulp powder. The fat content in all the three dried products packed in glass bottles (T_1) was found to retain more fat during storage. This may be because of less oxidation in these packages. This was in conformity with the findings of Hymavathi and Khader (2004), who were of the opinion that glass bottles retained more nutrients when long time storage was required in mango pulp powder.

The fat content of fresh drumstick fruits was 0.1 g/100 g whereas the fat content of the dehydrated products were found to be much higher. This may be because of less of moisture content which results in increasing the concentration of fat in the remaining mass.

5.1.1.4 Protein

The protein content was found to be influenced by the type of products made and storage period. The protein content in all the three dried products packed in four packaging materials reduced gradually with increase in storage period. Similar results were obtained by Lal *et al.* (2004) in dehydrated slices of Kachari (*Cucumis callosus*). . As per the results obtained by them the protein content of the dried slices of Kachari decreased with the advancement of storage period. This was also in conformity with the results obtained by Randhawa and Ranote (2004) in mushroom powder. This was further supported by Gupta (2006). According to him denaturation of protein may be brought about by heat in the presence of moisture. When denatured, the configuration of the native protein molecule is lost and specific immunological properties which distinguish most proteins are diminished. The protein content was found to be highest at the beginning of the storage period and lowest at the end of the storage period. Not much difference was found in the protein content of all the three dried products in all the four treatments.

The fresh value of protein content in drumstick fruits were reported to be 2.5 g/100 g whereas the protein content of the dehydrated products were found to be 2.20 g/100g.

5.1.1.5 Vitamin A

Vitamin A content varied with the type of dried product made and storage period. As the storage period increased a reduction in vitamin A content was observed in all the three dried products packed in four different packaging materials. Reduction in vitamin A content during storage might be due to photosensitive nature and oxidation as reported by Mir and Nirankarnath (1993)

in dehydrated mango. Similar results were reported by Sagar *et al.* (2004) in dehydrated carrot slices. According to them vitamin A content decreased in dried carrot slices during storage period which may be due to oxidation. Gupta (2006) opined that if heating occurs in the presence of oxygen, appreciable losses of Vitamin A occur. Among the three dried products, the vitamin A content was found to be higher in P_3 followed by P_2 and P_1.

Packaging material T_1 *i.e.*, glass bottles was found to be better for storing all the three dried products as it retains higher vitamin A as compared to PET bottles, polyethylene bags and aluminium foil pouches. This was supported by Hymavathi and Khader (2004) who stated that glass bottles retain more nutrients.

The fresh value of vitamin A content of drumstick fruits were reported to be 184 IU whereas vitamin A content of all the three dried products were found to be lesser.

5.1.1.6 Total Carbohydrate

Total carbohydrate of all the three dried products packed in four different packaging materials each was found to be influenced by storage period. The total carbohydrate content in all the three dried products decreased with increase in storage period. The total carbohydrate content was highest at the beginning of the storage period and lowest at the end of the storage period. Decrease in total carbohydrate over storage period was in conformity with the results obtained by Lal *et al.* (2004) in dehydrated slices of Kachari. This was also supported by Gupta (2006). According to him sugar and starch are degraded by prolonged heating at high temperature. Among the three dried products carbohydrate content was found to be higher for P_1 followed by P_2 and P_3.

The fresh value of total carbohydrate content of drumstick fruits were reported to be 3.7 g/100 g whereas total carbohydrate content of the dehydrated products were found to be greater. Similar results were reported by Lakshmi and Radha Priya (2004) in dehydrated drumstick flowers.

5.1.2 Assessment of organoleptic qualities during storage

Changes in organoleptic qualities of the dried products are discussed below.

The dried pulp was found to be in good condition till the end of the storage period. As the storage period increased organoleptic quality with respect to appearance, colour, flavour, taste and texture of the product decreased. This was in conformity with the findings of the Sethi *et al.* (1980) in various fruit products. It was substantiated by the findings of Lal *et al.* (2004) in dehydrated Kachari slices. According to them organoleptic quality of dehydrated slices declined with the advancement of storage period. Regarding the packaging materials, dried pulp packed in glass bottles scored more in sensory attributes like appearance, colour, flavour and taste but regarding the texture dried pulp packed in polyethylene bags had scored higher as compared to others.

5.1.2.2 Pulp Powder

The pulp powder remained in good condition till the end of the storage period. As the storage period increased organoleptic quality of the product decreased. This may be because of absorption of moisture as the storage period advanced and thereby subsequent caking of the product. Regarding pulp powder with respect to packaging materials, the pulp powder packed in polyethylene bags had scored highest for quality attributes like appearance and colour whereas pulp powder packed in glass bottles scored highest for quality attributes like flavour, taste and texture.

5.1.2.3 Dried pieces of fruits

The dried pieces of fruits were found acceptable till the end of the six month storage period. There was gradual decline in the organoleptic quality of dried pieces of fruits during storage. This was substantiated by similar results obtained by Sagar *et al.* (2004) in dehydrated carrot slices. According to them organoleptic score with respect to colour, flavour and texture decreased with increase in storage period. The dried pieces of fruit packed in polyethylene bags

had scored highest for colour and flavour and with regard to taste and texture, dried pieces of fruits packed in glass bottles scored the highest.

5.1.2.4 Reconstituted dried products

After rehydration of three dehydrated products *viz.*, dried pulp, pulp powder and dried pieces of fruits, the products were assessed for organoleptic qualities. In all the three reconstituted products quality attributes like appearance, colour and texture were found to be very good and more appealing by the judges. The quality attributes like taste and flavour were also good and found to be acceptable.

Among the three reconstituted products, dried pulp and dried pieces of fruits were found to be more acceptable as compared to pulp powder.

5.2 BOTTLED FRUIT PIECES IN BRINE

5.2.1 Assessment of changes in biochemical qualities during storage

Result on the changes in the biochemical constituents *viz.*, ascorbic acid, fibre, fat, protein, vitamin A and total carbohydrate during storage are discussed below.

5.2.1.1 Ascorbic Acid

The ascorbic acid content of bottled fruit pieces in brine were influenced by storage period. The ascorbic acid content could be analysed only up to four months because of complete spoilage of the products. With increase in storage period, the ascorbic acid content decreased significantly. The decrease in ascorbic acid content during storage period may be due to temperature and oxidative process. This was supported by Sagar and Kumar (2006). According to them decrease in ascorbic acid may be due to dilution of these nutrients per unit weight by increasing the mass due to absorption of water and high temperature during blanching of the sample. Similar findings were reported by Premi *et al.* (1999) in aonla fruits preservation by steeping. They opined that ascorbic acid content of aonla fruits decreased considerably during storage due to leaching of ascorbic acid into brine and destroyed during subsequent storage.

Ascorbic acid content of fresh drumstick fruits were reported to be greater than that of the bottled fruit pieces in brine. The loss of ascorbic acid may be due to washing, cutting and blanching. Similar findings had been reported by Rai *et al.* (2004), who stated that shredded cabbage and sliced cucumber lost about 20 per cent and 22 per cent respectively of the ascorbic acid during shredding and slicing.

5.2.1.2 Fibre

The packaging materials and storage period had not much influenced the fibre content of bottled fruit pieces in brine. There was no significant changes in fibre content during the entire period of storage though it decreases slightly over the storage period. Slight decrease in fibre content of bottled fruits pieces in brine might be due to increase in moisture and decrease in lignin, uronic acid and hemicellulose during blanching. This was in conformity with the result obtained by Guillen *et al.* (1995) in canned asparagus in brine. Ogunjobi *et al.* (2005) also observed a slight reduction in fibre during storage in fermented Iris potato slices in 2 per cent brine.

The fibre content in bottled fruit pieces in brine were found to be more or less similar to that of fresh drumstick fruits as reported to be 4.8 g/100 g. But the percentage of fibre content of bottled fruit pieces in brine was found to be quite lower as compared to the dried products. This may be because of presence of high moisture content in bottled fruit pieces.

5.2.1.3 Fat

The fat content in bottled fruit pieces in brine was influenced by storage period. The fat content in bottled fruit pieces in brine, packed in glass bottles and PET bottles were found to be more or less same. The fat content was found to be decreased with increase in storage period. Decrease in fat content of bottled fruit pieces in brine may be due to oxidation and hydrolyzation. Srivastava and Kumar (2002) opined that fats and oils became rancid by action of air (oxidized), water (hydrolyzed) and enzyme.

The fat content in bottled fruit pieces in brine were found to be bit lesser than that in the fresh samples which was reported to contain 0.1 g/100 g. Moreover fat content of bottled fruit pieces in brine were found to be quite lower than the dried products. This may be because of retention of moisture in bottled fruit pieces in brine as compared to other dried products.

5.2.1.4 Protein

Protein content of bottled fruit pieces in brine was influenced by storage period. The protein content in bottled fruit pieces in brine packed in two packaging materials decreased gradually as the storage period increased. Gradual decrease in protein content of bottled fruit pieces in brine might be due to blanching where interaction between various constituents might have occurred leading to the changes in amino acid composition of the original product and thus lowering the nutritive value. This finding was supported by result obtained by Rao and Rao (1972) in groundnut protein. Protein content was found to be higher at the beginning of storage period and lower at the end of the storage period.

The protein content of bottled fruit piece in brine were found to be lesser than that of the fresh fruit which was reported as 2.5 g/100 g.

5.2.1.5 Vitamin A

Vitamin A content of bottled fruit pieces in brine was influenced by storage period. The vitamin A content decreased with increase in storage period. Decrease in vitamin A content during storage might be due to oxidation by air. Srivastava and Kumar (2002) stated that there was slight destruction of vitamin A and carotene during cooking in water due to oxidation of air. Chavasit *et al.* (2002) reported vitamin A loss in candied mango and papaya during processing. Rapid loss of vitamin A on processing and storage of vegetables had also been reported by Chandrasekhar and Kowsalya (2000).

The vitamin A content of bottled fruit pieces in brine were found to be lesser as compared to that of the fresh fruits, which was reported to be 184

IU. But vitamin A content was found to be greater as compared to the dried products.

5.2.1.6 Total Carbohydrate

The total carbohydrate content of bottled fruit pieces in brine was influenced by storage period. With increase in storage period, the total carbohydrate decreased. Reduction in total carbohydrate content during storage might be due to hydrolysis of carbohydrate and subsequent conversion to sugars and minerals. This was substantiated by the results obtained by Ogunjobi *et al.* (2005) in fermented Irish potato slices in two per cent brine.

The total carbohydrate of bottled fruit pieces in brine were found to be lesser than that of the fresh fruits which was reported to be 3.7 g/100 g. The total carbohydrate of bottled fruit pieces in brine was also found to be lesser than the dried products developed.

5.2.2 Assessment of organoleptic qualities during storage

Changes in organoleptic qualities of the bottled fruit pieces in brine are discussed below.

5.2.2.1 Bottled fruit pieces in brine

The bottled fruit pieces in brine was found to be in good condition upto four months of storage period after which the product got spoiled due to microbial attack. As the storage period increased the organoleptic quality of the product decreased. This was in conformity with the findings of Sethi *et al.* (1980) in various fruit products.

Regarding the packaging material, only two types of packaging material were used *i.e.*, glass bottles and PET bottles. Glass bottled fruit pieces in brine scored highest for the quality attributes like appearance, colour, flavour, taste and texture.

Summary

6. SUMMARY

The present investigation entitled "Product development in drumstick (*Moringa oleifera* Lam.)" was carried out to explore the possibility of different product development in under-exploited crops like drumstick and to evaluate the suitability of packaging material for the products. The experiments were carried out in the Department of Processing Technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 2005-2006. Major findings of the study are summarized below.

Four products namely dried pulp, pulp powder, dried pieces of fruits and bottled fruit pieces in brine had been standardized and developed by using drumstick fruits. The biochemical and organoleptic qualities of the products packed in different packaging materials were evaluated during the storage period of six months.

Dried pulp packed in four type of packaging materials was found to be acceptable till the end of storage period though the ascorbic acid, fibre, fat, protein, vitamin A and total carbohydrate contents decreased with increase in storage period. The organoleptic quality was also found to be decreasing during storage period.

Pulp powder packed in four packaging materials showed similar trend as that of dried pulp and remained acceptable till the end of the storage period. All the biochemical attributes like ascorbic acid, fibre content, fat, protein, vitamin A and total carbohydrate contents in pulp powder reduce as the storage period advanced. The organoleptic quality was also found to be decreased with increase in storage period.

Dried pieces of fruits packed in four different packaging materials could be stored well upto six months of storage period though with advancement of storage period biochemical parameters like ascorbic acid, fibre, fat, protein, vitamin A and total carbohydrate contents decreased. The

monthly evaluation of organoleptic quality revealed that it decreased with increase in storage period.

Bottled fruit pieces in brine packed in two packaging materials were found to store well only for four moths after which it had to be discarded due to microbial attack. The biochemical parameters like ascorbic acid, fat, protein, vitamin A, fibre and total carbohydrate content and organoleptic quality decreased with increased storage period.

Among all the four products prepared *viz.*, dried pulp, pulp powder, dried pieces of fruits and bottled fruit pieces in brine, all the three dried products were found to have more fibre, fat and total carbohydrate as compared to those in the fresh drumstick fruit. However, ascorbic acid, protein and vitamin A were found to be less as compared to those in the fresh fruits. In case of bottled fruit pieces in brine, vitamin A retention was more as compared to dried products. However ascorbic acid, fibre, protein and fat were found to be lesser as compared to those in dried products as well as that of fresh drumstick fruits.

Regarding the organoleptic quality among all the four products prepared, dried pulp and pulp powder scored more. The appearance, colour, flavour, taste and texture were found to be highly appreciable. Dried fruit pieces were not found much appreciable but after reconstitution it was found to more appreciable. Fruit pieces in brine packed in glass bottles were found more acceptable than those in PET bottles. In all the quality attributes, glass bottled fruit pieces in brine scored more as compared to PET bottled fruit pieces in brine. For all the three dried products, the shelf life was found to be for six months whereas bottled fruit pieces in brine had a shelf life of only upto four months.

From the above study it is concluded that drumstick fruits can be made into various products either by dehydration or brining *viz.*, dried pulp, pulp powder, dried pieces of fruits and bottled fruit pieces in brine. And all these products can be incorporated in preparing various recipes. The finding

also revealed that all the three oven dried drumstick fruits and bottled fruit pieces in brine were highly nutritious. The findings of the present study revealed the fact that dehydrated drumsticks fruits either in the form of dried pulp, pulp powder and dried pieces of fruits or in the form of bottled fruit pieces in brine which are underutilized but rich in terms of nutrients like vitamins and minerals can be utilized to prepare secondary products like sambar, aviyal, soups etc. and to make use of them for value addition to overcome several nutritional problem.

Future line of work

- Similar product like powder can be tried out with leaves and flowers of drumstick
- Canning of drumstick fruits can be tried for export

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*Original not seen

Appendices

APPENDIX - I

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology,
College of Agriculture, Vellayani

Score card for assessing the organoleptic qualities of Dried pulp of Drumstick for four different packages

Criteria	Score	Samples			
		T_1 (glass)	T_2 (PET)	T_3 (Poly.)	T_4 (Al. foil)
Appearance					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Colour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Flavour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Taste					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Texture					
Very good	4				
Good	3				
Fair	2				
Poor	1				

Date :
Thanks for participation

Name :
Signature :

APPENDIX - II

KERALA AGRICULTURAL UNIVERSITY

Department of Processing Technology,
College of Agriculture, Vellayani

Score card for assessing the organoleptic qualities of Pulp powder of Drumstick for four different packages

Criteria	Score	Samples			
		T_1 (glass)	T_2 (PET)	T_3 (Poly.)	T_4 (Al. foil)
Appearance					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Colour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Flavour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Taste					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Texture					
Very good	4				
Good	3				
Fair	2				
Poor	1				

Date :
Thanks for participation

Name :
Signature :

APPENDIX - III

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Score card for assessing the organoleptic qualities of Dried pieces of Drumstick for four different packages

Criteria	Score	Samples			
		T_1 (glass)	T_2 (PET)	T_3 (Poly.)	T_4 (Al. foil)
Appearance					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Colour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Flavour					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Taste					
Very good	4				
Good	3				
Fair	2				
Poor	1				
Texture					
Very good	4				
Good	3				
Fair	2				
Poor	1				

Date :
Thanks for participation

Name :
Signature :

APPENDIX - IV

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Department of Processing Technology,
College of Agriculture, Vellayani

Score card for assessing the organoleptic qualities of Bottled fruit pieces of Drumstick for two different packages

Criteria	Score	Samples	
		T_1 (Glass bottles)	T_2 (PET bottles)
Appearance			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Colour			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Flavour			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Taste			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Texture			
Very good	4		
Good	3		
Fair	2		
Poor	1		

Date :
Thanks for participation

Name :
Signature :

APPENDIX - V

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Department of Processing Technology,
College of Agriculture, Vellayani

Score card for assessing the organoleptic qualities of reconstituted dried products

Criteria	Score	Samples		
		P_1	P_2	P_3
Appearance				
Very good	4			
Good	3			
Fair	2			
Poor	1			
Colour				
Very good	4			
Good	3			
Fair	2			
Poor	1			
Flavour				
Very good	4			
Good	3			
Fair	2			
Poor	1			
Taste				
Very good	4			
Good	3			
Fair	2			
Poor	1			
Texture				
Very good	4			
Good	3			
Fair	2			
Poor	1			

Date :
Thanks for participation

Name :
Signature :

APPENDIX VI

Specification for dehydrated vegetables

Product	General characteristics
Dehydrated vegetables	The product shall be prepared from wholesome vegetables free from blight, discoloration or fungi. Only the edible portion of the vegetables shall be used and it shall be free from stalks, peels, stems and extraneous leaves. The finished product shall be of good edible quality and shall reasonably reconstitute to its original shape and quality on boiling from fifteen minutes to an hour. The finished product shall be free from visible mould, insect or larvae.

APPENDIX VII

Specification for bottled vegetables

Product	Specification
Bottled vegetable	1. Head space in the can shall not be more than 1.6 cm. 2. The drained weight of the vegetable shall not be less than 55 percent 3. No preservative shall be added. 4. No artificial colour shall be present except in case of peas where permitted colour may be added. 5. The can shall not show any positive pressure at sea level and shall not show any sign of bacterial growth when incubated at 37°C for a week.

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APPENDIX-VIII

Nutritive value of fresh drumstick fruits per 100 gram

1	Ascorbic acid	120 mg
2	Fibre	4.8 g
3	Fat	0.1 g
4	Protein	2.5 g
5	Vitamin A	184 IU
6	Carbohydrate	3.7 g

PRODUCT DEVELOPMENT IN DRUMSTICK

(*Moringa oleifera* Lam.)

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Abstract of the
thesis submitted in partial fulfilment of the requirement
for the degree of

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Kerala Agricultural University, Thrissur

2006

Department of Processing Technology
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

ABSTRACT

The present investigation entitled "Product development in Drumstick (*Moringa oleifera* Lam.)" was carried out at the Department of Processing Technology, College of Agriculture, Vellayani, Thiruvananthapuram during the period 2005-2006.

The objective of the study was to develop and standardize new products, to evaluate the quality and shelf life of the new product and to assess the consumer acceptance of the new products. Four products namely Dried pulp, Pulp powder, Dried pieces of fruits and Bottled pieces in brine had been developed and standardized. All the products were evaluated based on biochemical, shelf life and organoleptic qualities at the time of preparation as well as during storage.

Ascorbic acid content in all the four products including three dried products and one bottled product were found to decrease with increase in storage period. Ascorbic acid content was found to be highest in dried pulp when stored in glass bottles, as compared to other three.

All other biochemical quality attributes *viz.*, fibre, fat, protein, vitamin A and total carbohydrate were found to decrease with increase in storage period in all the four products developed. Fibre, fat and total carbohydrate content were found more in all the three dried products than those in fresh drumstick fruits. But in case of bottled fruit pieces in brine it was found to be more or less similar to that of fresh one. Bottled fruit pieces in brine had high vitamin A content as compared to all other dried products.

Regarding the storage studies and organoleptic quality, all the three dried products *viz.*, dried pulp, pulp powder, dried pieces of fruits remained in good condition for upto six months, if properly packed. Bottled fruit pieces in brine were good only upto four months. So the lowest shelf life was found to be for bottled fruit pieces in brine.

Dried pulp was found more acceptable with regard to appearance, colour, flavour, taste and texture which is followed by pulp powder and dried pieces of fruits among the dried products. But after reconstitution dried pieces of fruits were found more acceptable. Bottled fruit pieces in brine were more acceptable with regard to appearance, colour and taste. The organoleptic qualities in all the four products decreased with increase in storage period.

From the above study it is concluded that under-exploited crops like drumstick especially drumstick fruit can be utilized to develop many value added products like dried pulp, pulp powder, dried pieces of fruits and bottled fruit pieces in brine. And suitable packaging material should be developed in order to make these products to last long to make it attractive to the consumer.