NUTRITIONAL EVALUATION OF MINOR TROPICAL VEGETABLES

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DECLARATION

I, Vanisree, K. (2000-16-06) hereby declare that seminar entitled "NUTRITIONAL EVALUATION OF MINOR TROPICAL VEGETABLES" have been prepared by me, after going through the various references cited here and has not been copied from my fellow students.

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INTRODUCTION

India is the second largest producer of the vegetables, which are being grown on 6.5 million ha area and produces 87 million tonnes of vegetable, which are capable to supply 210 g vegetables per caput per day against minimum requirement of 285g/caput/day.

As the dietary pattern in India is changing day by day people want change in food habit along with their way of liking. In such circumstances a new range of minor tropical vegetables are catching the attention of growers, retailers and consumers, Which are known to be the minor vegetables or rare vegetables. But the consumption of these vegetables is very less due to non-preference and ignorance (Chaurasia and Nirmal, 2001).

It has been reported that 19 promising but under-exploited vegetables for improving the nutritional status of tropical diet. The Indian council of Medical research reports a meagre consumption of 125 g of vegetables per capitum per day in Kerala as against the daily requirement of 150 g (Indira and Peter, 1989).

Average consumption of vegetables in Kerala (g/day)

Sl.No.	Food stuff	1993-94	1995-96	RDA*
1	Green leafy vegetables	16	20	40
2	Other vegetables	26	22	60
3	Roots and tubers	69	60	50

It has been opined that the intake of vegetables has been too low in our daily diet because we are not able to appreciate the vast potential of vegetables in our diet and therefore continue to depend too much on cereals (Manay and Shadaksharaswamy, 1995).

It has been found that the nutritive value of under utilized tropical plants had a good complement of amino acids, favourable amounts of minerals, sugars, lipids and fibre (Yeoh and Wong, 1993).

Furthermore, anti-nutritional factors such as chymotripsin and cyanides were not detected in these vegetables.

Consumption of these tropical vegetables has significant health promoting effects and can reduce the incidence of cardiovascular diseases, cancers, AIDS and various other degenerative diseases (Charanjith, Mani, 2001).

These minor vegetables can be classified based on the edible plant parts used and commercial utilization. They are

1. Green leafy vegetables
2. Other vegetables
3. Roots and tubers

NUTRITIONAL IMPORTANCE OF GREEN LEAFY VEGETABLES

Green leafy vegetables abound in our country are known to be the most inexpensive source of several vital nutrients. Leafy vegetables are appreciated because, they not only supply the protective nutrients and add variety to a monotonous diet, but also have an attractive taste, pleasing appearance and aroma.

The commonly consumed green leafy vegetables in India such as drumstick, spinach etc. are termed as 'Poorman's luxury' due to their unassuming way of production, response to basic health needs, their wide range of choices and essential cheapness.

The severity of micronutrient malnutrition widely prevalent in India can be easily reduced, if the consumption of green leafy vegetables is actively promoted, especially among the low income groups of the population. The affluent lot can also benefit by eating these vegetables as these contain antioxidants which offer protection against many chronic diseases like heart disease and certain types of cancers (Saxena, 1999).

Green leafy vegetables are one of the best sources of Vit. C, riboflavin and iron for vegetarians. They are rich sources of Betacarotene, folic acid, Ca and Vit. K.

Leafy vegetables are also a good source of dietary fibre, particularly soluble fibre and fatty acids (α-linolenic acid) which has hypocholesterolaemic and hypotrihlyceridaemic effects in humans. The matter of leafy vegetables are good proteins also (Saxena, 1999).

A daily intake of at least 100 g of fresh green leafy vegetables is recommended by the nutrition experts (Reddy, 1999). Besides the commonly consumed leafy vegetables in India, a great variety of less familiar green leafy vegetables are also used locally in different parts of the country.

The most commonly used minor green leafy vegetables are

1. Agathi
2. Chekkurmanis
3. Colocasia leaves (green)
4. Curry leaves
5. Drumstick leaves
6. Fenugreek leaves
7. Gogu
8. Ponnaganni

9. Spinach
10. Tamarind leaves (tender)
11. mint
12. Coriander leaves
13. Cowpea leaf
14. Paruppukerai
15. Pumpkin leaves

Nutritional composition of some common minor green leafy vegetables are presented in Table 1.

NUTRITIONAL EVALUATION OF GREEN LEAFY VEGETABLES

Carbohydrates

According to Shingade *et al.* (1995), the unconventional leafy vegetables contained more carbohydrates than conventional sources. The drumstick leaves (11.5%) were superior in carbohydrate content when compared to spinach, cowpea etc.

The mean soluble carbohydrate content of selected leafy vegetables varied from 0.63 to 2.1.

In drumstick leaves as reported by Rao *et al.* (1979) the mean carbohydrate content in dry weight basis varied from 2.7 g/100 g - 4.7 g/100 g.

It can be seen found that the soluble carbohydrate content of leafy vegetables was in general higher than the starch content of the leafy vegetables.

This is supported by the observations of Rao *et al.* (1979) who reported higher content of sugar compared to starch in green leafy vegetables studied.

Dietary fiber

Dietary fiber, the sum of polysaccharides are lignin which are not digested by endogenous secretions of

human GI tract is effective in reducing the incidence of obesity, hypercholesteremia, heart disease, diverticular disease and colon disease (Jrowell, 1976).

According to Reddy (1999) benefits of dietary fibre can be had by increased consumption of GLV which also increased the faecal bulk and prevents constipation.

According to Gupta *et al.* (1989) the tender leaves of colocasia, drumstick, fenugreek, neem are good sources of neutral detergent fibre and acid detergent fibre.

According to Bressani *et al.* (1988) fibre content of spinach is 0.7 per cent.

Protein

Green leafy vegetables are good sources of protein and the dry matter of leaves contain as much as legumes (Reddy, 1999).

Nag and Matai (1991) estimated the amino acid composition of the cytoplasmic fraction of leaf protein from some green leafy vegetables and reported an excellent balance of essential amino acids in leaf proteins.

Handique (1993) detected 12 free amino acids including 7 E.A.A. in certain unconventional vegetables.

Mint is rich in protein, nitrogen (Rao *et al.*, 1979).

Fat

100 g green leafy vegetables like gogu and fenugreek provide on an average 0.34 g of fat and these leaves contain high amount of α-linoleic acid (NIN, 1990).

Some polyunsaturated fatty acids are also present besides the vitamins (Davidson *et al.*, 1973).

Vitamins and minerals

Vijayaraghavan (1996) indicated that green leafy vegetables like spinach, drumstick leaves etc. which are affordable by the rural and urban poor are major inexpensive sources of provitamin A.

The most rational and sustainable longterm solution to control vitamin A deficiency is to ensure inclusion of green leafy vegetables (Kowsalya and Chandrasekhar, 1999).

Commonly consumed green leafy vegetables in India such as fenugreek, mustard, mint, coriander and curry leaves are rich and inexpensive sources of ß-carotene (Bressani *et al.*, 1986; Gopalan, 1989; NIN, 1993; Thimmayamma, 1996).

The carotenoid content of dark GLV are associated with lower risk of certain Epithelial cancers (Reddy, 1999).

A study conducted by Kowsalya and Chandrasekhar (1999) indicated that drumstick leaves in it's raw form had maximum total carotene and ß-carotene.

Coriander leaves are characterized by higher level of niacin.

GL vegetables are rich in vitamin C which is required to keep the gums in healthy condition (Menon, 1980; Gopalan *et al.*, 1989).

Spinach, drumstick, mint, coriander etc. are equally good sources of vitamin C as fruits (Sreeramulu *et al.*, 1983a; Thimmayamma and Pasricha, 1996).

Drumstick leaves are reported to be richer in ascorbic acid (220 mg/100 g) (Peter, 1979; Shingade, 1995).

According to Manay and Shadaksharaswamy (1995) drumstick leaves were considered useful in scurvy and catarrhal affection.

Chekkurmanis one of the popular green leafy vegetable in South India, commonly known as multi-vitamin and multi-mineral packed leafy vegetable (Ramachandran *et al.*, 1980) is very rich in nutritive value.

Lakshmi and Vimala (1998) conducted studies for the development of nutritious dehydrated powders and blends of green leafy vegetables vegetables. Curry leaf powder was found to be rich in fiber, vitamin C, ß-carotene and Cu, while gogu and mint powders were fair sources of all the nutrients.

Green leafy vegetables are rich in minerals especially Fe and Ca (Nordeide *et al.*, 1996). Other minerals like P, Mg, Na, K, Cu, I, S and B are also detected in these vegetables.

Drumstick leaves are rich in S, Zn and B (Chavan, 1996). Apart from Ca, P, Fe, Cu, I, drumstick leaves also contain tocopherols (Vit. E) Estrogenic substances and some important enzymes (Gopalan, 1982).

The leaves are good sources of protective nutrients, which are essential for healthy vision, bones, blood and skin.

According to Imugi and Potter (1983) cowpea leaves are rich in minerals like iron, calcium, phosphorus and Zinc.

In order to make green leafy vegetables available to armed forces at high altitudes, deserts and seas, instant vegetable-dhal curry mixes based on spinach and drumstick leaves were developed at the Defense Food Research Laboratory, Mysore.

ANTI NUTRITIONAL FACTORS IN GREEN LEAFY VEGETABLES

Despite the high level of nutrients, the main constraint to the nutritive value of green leafy vegetables is the presence of some anti-nutritional factors like oxalates and nitrates in the leaves (Sadik, 1971; Singh and Saxena, 1972; Cheeke and Bronson, 1980; Gupta and Wagle, 1985). Besides these, the presence of phytates and hydrocyanic acid are also reported in certain leaves.

Oxalates

Oxalate levels in foods are of concern, because, free oxalates bind essential dietary divalent minerals, primarily Ca and make them nutritionally unavailable. The absolute amounts of minerals are therefore little value, unless considered in relation to the oxalic acid content. The calcium oxalates formed may accumulate resulting in oxalurea or kidney stones (James, 1968; Singh *et al.*, 1971; Gopalan *et al.*, 1989; Sukumar, 1997).

Certain plants such as spinach are known to contain rather high levels of oxalic acid. However, there is little evidence to substantiate the claim that the ill effects produced by the ingestion of these leaves are due to the presence of oxalic acid (Liener, 1980).

According to Reddy (1999) certain green leafy vegetables such as spinach and gogu are rich in oxalic acid and hence individuals prone to renal calculi should avoid such foods.

Gupta and Wagle (1988) observed an oxalate content of 8.69% in spinach, while in chenopodium and celosia (Prakash *et al.*, 1993; Prakash *et al.*, 1995).

According to Shingade *et al.* (1995) the unconventional leafy vegetables in general contained less

Proximate principles: Green leafy vegetables

Sl. No.	Name of the vegetable	Moisture (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	CHO (g)	Energy (KCal)	Ca (mg)	P (mg)	Fe (mg)	Rich In
1	Agathi	73.1	8.4*	1.4	3.1	2.2	11.8	93	1130*	80	3.9	Protein, Ca
2	Chekkurmanis	73.6	6.8	3.2	3.4*	1.4	11.6	03	570	200*	28.0*	Fe, energy, P, Ca, all
3	Colocasia leaves (green)	82.7	3.9	1.5	2.2	2.9	6.8	56	227	82	10.0	Fe
4	Curry leaves	63.8	6.1	1.0	4.0	6.4*	18.7*	108	830	57	0.93	Ca, fibre
5	Drumstick leaves	75.9	6.7	1.7	2.3	0.9	12.5	92	440	70	0.85	Fair source of Pr, Ca, P
6	Fenugreek leaves	86.1	4.4	0.9	1.5	1.1	6.0	49	395	51	1.93	Fair Ca, Fe
7	Gogu	86.4	1.7	1.1	0.9	-	9.9	56	172	40	2.28	Fair CHO
8	Ponnaganni	77.4	5.0	0.7	2.5	2.8	11.6	73	510	60	1.63	Ca, Pr
9	Spinach	92.1*	2.0	0.7	1.7	0.6	2.9	26	73	21	0.14	Fair in all
10	Tamarind leaves (tender)	70.5	5.8	2.1*	1.5	1.9	18.2*	115*	101	140	0.30	CHO, P
11	Mint	84.9	4.8	0.6	1.9	2.0	5.8	48	200	62	15.6	Fair Ca, Fe
12	Coriander leaves	86.3	3.3	0.6	2.3	1.2	6.3	44	184	71	1.42	Fair Ca, P
13	Cowpea leaf	89.0	3.4	0.7	1.6	1.2	4.1	38	290	58	20.1	Fe
14	Pamppukkeri	90.5	2.4	0.6	2.3	1.3	2.9	27	111	45	14.8	Fair Fe
16	Pumpkiri leaves	81.9	4.6	0.8	2.7	2.1	7.9	57	392	112	-	P

* (NIN, 1989)

Vitamin content of green leafy vegetables

Sl. No.	Name of the Vegetables	Carotene (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Folic acid		Vitamin C (g)	Colin (mg)	Rich in
						Free	Total			
1	Agathi	5,400	0.21	0.09	1.2	-	-	169	-	Fair Vit.C, carotene
2	Chekkurmanis	5,706	0.48*	0.32	2.6*	-	-	247	-	Vit. C
3	Colocasia leaves	12,000*	0.06	0.45*	1.9	-	-	63	-	Carotene
4	Curry leaves	7,560	0.08	0.21	2.3	23.5	93.9	4	-	Total Folic acid
5	Drumstick leaves	6,780	0.06	0.05	0.8	-	-	220	-	Vit.C
6	Fenugreek leaves	2,340	0.04	0.31	0.8	-	-	52	-	Fair Riboflavin
7	Gogu	2,898	0.07	0.39	1.1	-	-	20	-	
8	Ponnaganni	1,926	0	0.14	1.2	-	-	17	-	
9	Spinach	5,580	0.03	0.26	0.5	51.0*	153.0*	28.0	-	Carotene, Folic acid
10	Tamarind leaves (Tender)	250	0.24	0.17	4.1-	-	-	3	-	Niacin
11	Mint	1,620	0.05	0.26	1.0	9.7	114.0*	27	0	Total Folic acid
12	Coriander leaves	6,918	0.05	0.06	0.8	-	-	4	-	Carotene
13	Cowpea leaf	6,072	0.05	0.18	0.6	-	-	4	-	Carotene
14	Paruppukeeri	2,292	0.10	0.22	0.7	-	-	29	-	Fair Vit. C
15	Pumpkin leaves									

* (NIN, 1989).

oxalates as compared to cultivated vegetables there by indicating good palatability and safe use in human diet.

Guerrero and Isasa (1997) analyzed the oxalic acid content of leaves of chenopodium species and found moderate levels of oxalic acid.

Mathew (2000) analyzed the mean oxalate content of eight leafy vegetables (given in the table).

Oxalate content of different leafy vegetables

Sl.No.	Variety	Summer	Rainy	Mean
1	Akshrakeera	0.78	0.83	0.80
2	Arakeera	0.86	0.53	0.70
3	Basella	0.27	0.18	0.23
4	Bengalkeera	1.25	0.91	1.08
5	Centella	0.68	0.70	0.69
6	Horse purslane	0.50	0.45	0.48
7	Kangkong	0.51	0.43	0.47
8	Water leaf	0.28	0.23	0.26

Nitrates

The usual human dietary intake is about 100 mg per day (White, 1975). The nitrate may get converted into nitrite and nitrosamines in the body (Jannenbaum *et al.*, 1978). Only in such circumstances, the level of nitrate in the diet is of concern. Normally, dietary nitrate is excreted in the urine without further conversion (Jannebaum, 1979).

Deutsch (1977) pointed that healthy adults need not be concerned about the presence of nitrate and oxalate compounds, in green leafy vegetables, as the leafy greens make up only a fraction of the daily intake of these anti-nutritional factors. More than 100 g of daily fresh green intake is needed to raise the nitrate and oxalate levels. According to Deutsh (1977) and Marderosian *et al.* (1979), oxalates and nitrates become

more of a problem, when the plants are grown under stress.

Gupta and Wagle (1988) reported a nitrate content of 5.36 percent in spinach. Nitrate content of leafy vegetable in A.P., varied from 3 to 270 mg/kg (Gundimeda *et al.*, 1993).

In A.P. the nitrate content of the leafy vegetables contributed to 1.38% of the total nitrate intake (Gundimeda *et al.*, 1993).

According to Prakash *et al.* (1993) nitrate content in chenopodium auinva and celosia varied from 0.26 to 0.51% and 0.19 to 0.46% respectively.

According to Vera *et al.* (1992) lower rates of fertilizers should be recommended commercially to reduce the nitrate concentration in leafy vegetables such as spinach.

Nitrates accumulation can interfere with respiratory function and indices the accumulation of Se, Hg, Cd which poisonous. The mean nitrate content of eight leafy vegetables as analyzed by Mathew (2000).

Nitrate content of different leafy vegetables

Sl.No.	Variety	Summer	Rainy	Mean
1	Akshrakeera	0.20	0.19	0.20
2	Arakeera	0.43	0.13	0.28
3	Basella	0.11	0.11	0.11
4	Bengalkeera	0.32	0.54	0.43
5	Centella	0.49	0.15	0.32
6	Horse purslane	0.12	0.36	0.24
7	Kangkong	0.53	0.17	0.35
8	Water leaf	0.20	0.33	0.27

NUTRITIONAL IMPORTANCE OF OTHER VEGETABLES

Vegetables are rich sources of certain essential vitamins; minerals, proteins and dietary fiber provide

additional calories. The world scenario reveals that India is the second largest producer of vegetable next to China contributing about 12.22% of the world's vegetable production.

Vegetables considered as protective supplementary food as they contain large quantities of minerals, vitamins and essential amino acids, which are required for normal functioning of the human metabolic processes.

They are important to neutralize the acids produced during digestion and also useful as roughage. Peas and beans are enriched with proteins. Ca, P and Fe are the important minerals, which are lacking in cereals and are available in abundant quantities in vegetable like beans.

It has been estimated that 100 g of tropical vegetables can provide 60-140 mg of vitamin C, 100 mg folic acid, 4-7 mg iron and more than 200 mg Ca (Dhankar, 2001).

Vegetables are rich sources of dietary fiber ranging from 0.2 mg/100 g edible portion.

The commonly consumed tropical minor vegetables

1. Bottle gourd
2. Colocasia stem
3. Coccinia -Ivy gourd
4. Ridge gourd
5. Drumstick
6. Field bean
7. Sword bean
8. Winged bean
9. Dolichos bean
10. Cluster bean

Proximate principles of minor tropical vegetables

Sl. No.	Name of the Vegetable	Moisture	Protein	Fat	Minerals	Fibre	CHO	Energy	Ca	P	Fe
1	Bottle gourd	96.1	0.2	0.1	0.5	0.6	2.5	12	20	10	0.46
2	Colocasia stem	94.0	0.3	0.3	1.2	0.6	3.6	18	60	20	0.50
3	Drumstick	86.9	2.5	0.1	2.0	4.8	3.7	26	30	110	0.18
4	Field beans	86.1	3.8	0.7	0.9	1.8	6.7	48	210	68	0.83
5	Ridge gourd	95.2	0.5	0.1	0.3	0.5	3.4	17	18	26	0.39
6	Snake gourd	94.6	0.5	0.3	0.5	0.8	3.3	18	26	20	1.51
7	Sword bean	87.2	2.7	0.2	0.6	1.0	3.4	21	25	24	0.90
8	Winged bean	-	2.9	-	-	2.6	-	-	330	-	1.70
9	Dolichos bean	-	3.8	-	-	1.8	-	48	210	-	1.70
10	Cluster bean	81.0	3.2	0.4	1.4	3.2	10.8	16	130	57	1.08

Proximate principles of minor tropical vegetables (Vitamin content)

Sl. No.	Name of the Vegetable	Carotene (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Folic acid		Vitamin C (mg)
						Free	Total	
1	Bottle gourd	0	0.03	0.01	0.2	-	-	0
2	Colocasia stem	104	0.07	0.07	0.1	-	-	3
3	Drumstick	110	0.05	0.07	0.2	-	-	120
4	Field beans	187	0.10	0.06	0.7	-	-	9
5	Ridge gourd	33	-	0.01	0.2	-	-	5
6	Snake gourd	96	0.04	0.06	0.3	7.5	15.5	0
7	Sword bean	24	0.08	0.08	0.5	-	-	12
8	Winged bean	-	0.06	0.12	-	-	-	37
9	Dolichos bean	-	0.1	0.06	-	-	-	9
10	Cluster bean	198	0.09	0.03	0.6	50	144	49

The nutritional composition of the some common minor vegetables are presented in Table

NUTRITIONAL EVALUATION OF VEGETABLES

Carbohydrates

Carbohydrates are present largely in the form of sugars and starches while the indigestible celulosic materials provide roughage in the vegetables.

Vegetables also supply proteins, carbohydrates and dietary fibre. According to Malhrotra *et al.* (1975) the carbohydrate content of cluster bean is 20-30.7% where as according to Aykyroyd (1941) it is 9.9%.

Proteins

Proteins are present in leguminous and leafy vegetables and they are needed for the repair and maintenance of body tissues and synthesis of enzymes, co-enzymes and hormones.

Winged bean protein as analyzed by Anju (1998) ranged between 1.9-2.9%.

Winged bean protein is high (30-39%), In lysine 8% of the total amino acid. It's seeds, pods and leaves have high levels of protein (NAS, 1975).

Studies conducted by Rajesh and Bhanergee (2001) revealed that dolichos bean contains moderately well balanced amino acids and rich in proteins.

Fats

As fat content is very less. No studies included.

Vitamins and minerals

Vitamins are complex organic substances that are required for health and are effective in small amounts.

Vitamin A is synthesized in the body but it's synthesis requires certain compounds (carotenes) that are obtained from many vegetable species.

Red and yellow vegetables are particularly rich in carotenes, a deficiency of which leads to poor night vision.

Vitamin B (thiamine), B_2 (riboflavin) and B_6 (pyridoxine) occur in vegetables particularly in dark green vegetables and legumes. Deficiencies of which are responsible for the two prevalent diseases in tropical countries, beriberi and pellagra.

Almost all vegetables contain vitamin C over cooking of vegetable can lead to almost complete loss of this important vitamin.

MacFarline *et al.* (1990) through a study showed that a modest addition of vitamin C to meal would help to increase the bioavailability of iron. Vegetables are important sources of vitamin C and it enhances iron absorption.

Vegetables are also a major source of minerals. Some important minerals supplied by vegetables include Ca and P.

Fruits of moringa are reported to be rich in vitamin B and vitamin C and minerals (Brown, 1971).

ANTI-NUTRITIONAL FACTORS IN VEGETABLES

The most important anti-nutritional factors present in some vegetables are trypsin inhibitors, phytates, oxalates, tannins, lectins and goitrogens. They interfere with the utilization of other nutrients like proteins, minerals like iron, zinc, Ca and iodine (Gopalan *et al.*, 1971).

Anti-nutritional factors	Source
1. Trypsin inhibitors	Plant foods like legumes
2. Tannins	Winged bean, hyacinth bean
3. Oxalates	Seed coat of legumes, Vegetables
4. Goitrogensanti-thyroid Substances	Vegetables and legumes Cruciferous vegetables

Anti-nutritional factors	Action
1. Trypsin inhibitors	Inhibit the activity of trypsin and interfere the digestibility and utilization of protein
2. Phytate	Bind Fe, Zn, Ca and Mg and Makes unavailable
3. Tannins	Bind with Fe and interfere With Fe absorption
4. Oxalates	Interfere with Ca absorption forming insoluble salts (Ca oxalates)
5. Goitrogens	Interfere with iodine uptake leads to iodine deficiency

The seeds of winged bean contain compounds that interfere with protein digestion (NAS, 1975a). The dried seeds were found to contain powerful trypsin inhibitors (Hettiarachely *et al.*, 1978).

Adimorah (1979) reported toxic and pharmaceutically active constituents including agglutinating and anti-triptic factors in the seeds and cyanide in the stems.

Singh *et al.* (1987) reported the specific haemagglutinating activity, trypsin inhibitor and saponin content of winged bean seed as 3.92 Hua/g sample.

Harder (1994) reported accumulation of aluminum in the edible parts of the winged bean plant.

Kadam *et al.* (1987) found that processing methods eliminated substantial amounts of tannins, phytates, protease inhibitors, haemagglutinins and saponins.

Jack bean mean contains a thermo labile toxic principle (lectins) causing hemorrhage of the mucous lining of the stomach and of the intestines (Indira, 1988).

Oxalates known to interfere with Ca absorption by forming insoluble salts with calcium. Dietary oxalates can be absorbed and contribute to increased excretion of oxalates in urine. High oxalate excretion may predispose to oxalate crystals leading to urinary stones.

Srikantha *et al.* (1978) reported that the anti nutritional factors in winged bean except that tripsin inhibitor activity has been found and some tannin is present in the peel.

NUTRITIONAL IMPORTANCE OF ROOTS AND TUBERS

Underground tubers are storage organs occur at higher biomass in drier sites because they store food and water during periods of climatic stress (Andersen, 1987).

Tubers of Amorphophallus, nanthosoma, are considered very nutritious and are consumed in various ways in several parts of the country.

Coco yam, taro, yam bean and elephant foot yam are the important minor tuber crops. This group of crops has the potential to produce significantly high amount of food per unit area.

The calorific yield per unit area of these crops is comparatively high because they are more efficient in

converting atmospheric Co_2 into carbohydrates (Dhankhar, 2001).

CHO are ordinarily the cheapest form of calories and supply the bulk of calories. Majority of the root and tuber crops are rich sources of carbohydrates, which are mainly the fuel that provides bulk to the diet and energy to keep the body engine running.

The carbohydrates synthesized and stored in the form of starch in the underground tubers and roots provide necessary energy in human diet.

According to the FAO, about 400 million people of 26 tropical countries get approximately 300 Kcals per day from tubers alone (Ghosh, 2001).

Tropical roots and tubers are categorized as energy rich food crops due to their high starch content.

Root crops are important energy sources which are very easy to produce and the tubers used as food, as animal food and also being increasingly used as source of raw material in certain industries (Mandal, 1993).

In average diet in India, roots and tuber crops account for only 2.3% of the calories derived from cereals and 1.4% of the calories derived from total food.

Besides providing energy, fats mainly help to provide tasks and flavors, which make the carbohydrate and protein palatable and fit to eat.

The commonly consumed minor roots and tubers are

1. Amorphophallus/Elephant foot yam
2. Coleus
3. Colocasia/Taro
4. Canna
5. Yam/Dioscoria
6. Yam bean

Nutritional composition of commonly consumed roots and tubers are showed in the table.

NUTRITIONAL EVALUATION OF ROOTS AND TUBERS

Secondary tubers (off shoots of the main tubers) are important carbohydrate foodstuffs and are boiled or fried and used as a table vegetable.

Tropical roots and tubers are categorized as energy rich food crops due to their high starch content yam (18-25%) and aroids (19-21%).

The tubers are reported to have a starch content ranging from about 10 to 25 per cent, which is easily digestible.

The yields of starch varied from 7 to 14.3%. The starch content in Amorphophallus is reported by the range is 4-18 per cent (Kay, 1975; Rajendran *et al.* (1977).

Arrow root is most famous for it's fine, easily digested starch which is exported due to its high price. Taro is rich in starch, low in protein and fat. Taro starch can be used in baby foods, hypoallergenic foods and as a cereal substitute in diets for victims of celiac disease (NAS, 1975).

The dietary fiber content in white yam has been reported as 16.3% and white yam diets may protect against cancers of the colon and rectum (Dhankar, 2001).

Protein

The tubers contain 2-3% protein but are deficient in lysine, methionine and cysteine.

In coleus tubers Indira and Kurien (1973) registered a range of 8.3 to 8.7% proteins, Hrish and Mohankumar (1976) recorded 1.4% protein and Rajmohan (1978) recorded 1.42% protein.

Winged bean tubers have a protein content of 8-20 per cent.

In amorphophallus tuber protein varied from 5.63 to 10.50% in different portions of tubers (Shanmugam *et al.*, 1975).

Fat

As fat content is very low in roots and tubers no studies are included. The range being 0.1% in coleus to 0.7 in Trapa.

Vitamins and minerals

The tubers are reported to be rich in vitamin A, B and minerals like Ca and P (NAS, 1975).

Sarnaik and Peter (1976) reported that corms of colocasia contain 1.7% minerals and appreciable quantities of Ca, P, K and vitamin like A and B_1.

Taro, yam and Amorphophallus are rich in B-complex vitamins like B_1 and B_2.

Amorphophallus, yam bean rich in minerals like Ca.

ANTI-NUTRITIONAL FACTORS IN ROOTS AND TUBERS

Some of the anti-nutritional components such as digestive enzyme inhibitor in taro and acridity principles in aroids are identified and they can be reduced to safe limits through effective processing techniques, such as, removal of thick layer of skin and a longer period of cooking (Dhankhar, 2001).

Kortt (1980) indicated that the anti-nutritional factors in winged bean tubers have been found that some tannins are presented in the peel.

Seal (1970) reported that Amorphophallus tubers contain oxalic acid, which should got rid by thorough boiling and washing.

Proximate principles of miner tropical roots and tubers

Sl. No.	Name of the vegetable	Moisture (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	CHO (g)	Energy (KCal)	Ca (mg)	P (mg)	Fe (mg)	Rich In
1	Amorphophallus	78.7	1 2	0 1	0 8	0 8	18 4	79	50	34	0.6	Ca
2	Coleus	77 6	1 5	0 1	0 9	0 4	19 7	-	-	-	-	Fair CHO
3	Colocasia	73 1	3 0	0 1	1.7	1 0	21 1	97	40	140	0.42	CHO, Ca
4	Canna	7.3	1 1	0 4	19	0 5	24	-	20	-	0.5	Fair CHO
5	Yam	69.9	1.4	0 1	1.6	1.0	26 0	111	35	20	1.19	CHO, Energy, Fe
6	Xanthosoma	70-77%	1 3-3 7	0 2	-	0 6	17	-	-	-	-	Fair protein

- Vitamin content of minor tropical roots and tubers

Sl. No.	Name of the vegetable	Carotene (µg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Folic acid		Vitamin C	Rich in
						Free	Total		
1	Amorphophallus	260	0.06	0.07	0.7	-	-	0	
2	Coleus	-	-	-	-	-	-	-	
3	Colocasia	24	0.09	0.03	0.4	16.0	54.0	0	
4	Canna	-	-	-	-	-	-	-	
5	Yam	78	0.08	-	0.7	0.9	17.5	-	
6	Xanthosoma	-	-	-	-	-	-	-	
7	Yam bean								

Cyanogens occur in some tuber crops. They are dhurrin and linamarin, cyanogens are glycosides that readily yield HCN and causes dysfunction of the central nervous system, respiratory failure and cardiac arrest (D'mello, 2000).

THERAPEUTIC SIGNIFICANCE OF VEGETABLES

The main purpose vegetables in a human diet are they embellish the existing diet with nutrients, enrich the staple main food, make it more palatable and improve the digestion and sometimes they have a curative action. Consumption of diets rich in vegetables had a decreased risk of cardiovascular diseases, hypertension and certain forms of cancer (Ames *et al.*, 1993).

This protective action of vegetables can be attributed to

1. The presence of increased dietary fiber
2. Bioactive principles
3. The presence of protective micronutrients such as vitamin A, E, C and Se.

I. DIETARY FIBRE

The dietary fiber protects against colon cancer have been suggested by several mechanisms.

1. By increasing fecal bulk, which in turn dilutes the concentration of carcinogens in the feces.
2. By changing bacterial composition in the colon, which leads to deactivation of carcinogenic metabolites.
3. By binding carcinogens in the bowel.
4. By lowering the fecal pH.
5. By inducing structural, functional and chemical changes in the gut mucosa including altering rates of cell proliferation.

6. By inhibiting the production of butyric acid, a differentiating agent that also serves as an energy source for cell proliferation.

7. By altering bile acid metabolism.

8. By accelerating the fecal transit time.

It is insoluble fibre, which includes cellulose, lignins and some hemicellulose, which is responsible for decreasing risk of colon cancer.

It is found in abundance in the skin of vegetables. Thus a diet rich in vegetables is recommended.

II. BIOACTIVE PRINCIPLES FOUND IN VEGETABLES

Plant foods such as vegetables are an important group with anticarcinogenic effect. Their anti-carcinogenic activity can be attributed to

1. Inhibition of bacterial conversion of nitrates to nitrite the precursor of nitrosamine.
2. Activation of the detoxification enzyme system.

1. DITHIOLTHIONES AND ISOTHIOCYANATES

They are found in cruciferous vegetables. They protect against cancer by (a) inhibiting enzymes that activate carcinogens, (b) by inducing detoxifying agents (Abdullaer, 1993).

2. PHYTO OESTROGENS

Includes isoflavonnes and lignins which are found in certain legumes. They can be eliminated by modern milling techniques.

Lignins are important since they are anti-proliferative and growth inhibiting.

They are weakly estrogenic and can compete with steroid hormones for various enzymes. They also stimulate production of sex-hormone binding globulin in the liver (Abdullaer, 1993).

3. FLAVONOIDS

They found in certain vegetables. Quercetin, Kaemferor and myricelin are flavonnes widely distributed in vegetables.

Flavonoids in general function as potent anti-oxidants and thus decrease cancer risk in humans.

4. PROTEIN INHIBITORS

They are widely distributed in certain legumes. They inhibit the action of protease enzyme, which is believed to contribute to the invasive capacity of some cancer cells.

5. PHYTIC ACID (INOSITOL HEXAPHOSPHATE)

It found in certain pulses. It is thought to control cell proliferation.

6. GLUCOSINOLATES

Found in cruciferous vegetables is the most important intracellular anti-oxidants protecting the cells against O_2 free radicals (Frances chi, 1991).

7. SAPONINS

Are found in some legumes like soyabean.

They exhibit cytotoxic effects and growth inhibition against a variety of cells. They bind to bile acids and reduce their recirculation. They have known mutagenic inhibiting activity in animals (Birt and Bresnick, 1991).

The bioactive components, their sources and mechanism of action are shown in the table.

Component	Source	Mechanism of action
1. Dithiolthiones and Isothiocyanates	Cruciferous vegetables	Inhibit enzymes Activates detoxifying factors
2. Phytoestrogens Isoflavonnes Lignins	Pulses and legumes	Anti-proliferate Competes with steroid hormones Stimulates production of sex hormone binding globulin in the liver
3. Flavonoids	Vegetables, cruciferous vegetables and cucurbits	Potent antioxidants Inhibits protease enzyme
4. Protease Inhibitors	Pulses and legumes	Control cell Proliferation
5. Phytic acid	Pulses and legumes	Anti-oxidant Inhibits benzopyrene
6. Glucosinolates	Cruciferous vegetables	Activates glutathione enzymes
7. Saponins	Legumes	Anti-oxidants

III. MICRONUTRIENTS

The main micronutrients present in vegetables and fruits and showing strong anti-carcinogenic effect include

1. Vitamin A
2. Vitamin C
3. Vitamin E
4. Selenium

They act as strong anti-oxidants and are involved in DNA and cell maintenance and repair. They specifically protect DNA and cell membrane against oxidative damage by carcinogens like free O_2 radicals, methyl groups and hydroxyl groups. These can react with proteins, DNA and RNA forming adducts. They can also saturate the double bonds of fatty acids of cell membrane thereby altering the structure and function.

The micronutrients scavenge these reactive groups and interrupt the oxidative chain reaction (Valsecchi, 1992).

Selenium: The Se besides acting as antioxidant activates the Se dependent glutathione peroxide, which in turn can act as detoxifying agents.

Vitamin A: also plays a role in regulation of epithelial cell differentiation and thereby control cell growth (Shibata, 1992; Pandey, 1995).

Vitamin E: enhances the anti-oxidative property of Se and carotenoids by keeping them in the reduced state. It can also inhibit the action of nitrosamines.

Vitamin C: a strong anti-oxidant decreases the risk of cancer in animals. But since this is not synthesized in humans, the results of animal studies can not be wholly applied to human.

CONCLUSION

To conclude I would like to tell the range of the nutrients present in the 3 groups of vegetables.

SL No.	Minor vegetables	CHO	Proteins	Fat	Fiber	Carotene	Vit. C	Fe	Ca
1	Green leafy vegetables	2.9-18.7	1.7-8.4	0.6-3.2	0.6-6.4	250-12000	3-247	3-28	73-1130
2	Other vegetables	2.5-10.8	0.2-3.8	0.1-0.4	0.5-4.8	24-198	3-120	0.3-1.7	20-120
3	Roots and tubers	1.7-26.0	1.1-3.0	1.1-3.0	0.4-1.0	0.1-0.4	24-78	0-5	0.4-1.19

(NIN, 1999)

It has been indicated that almost all the vital nutrients are rich in green leafy vegetables when compared to other two groups. Due to unawareness or non-preference people are ignoring these green leafy vegetables. So by encouraging nutritional education programmes and producing these vegetables at household levels by kitchen garden can improve the consumption level as well as health status of the individual.

Malnourished children will be a burden to the nation. Fortunately the importance of vegetables for nutritional securing and health is becoming better accepted now a day. Among the vegetables minor tropical vegetables are the best answers to micronutrient deficiencies.

Even though fractional quantities of anti-nutritional factors present in these vegetables they do not affect the healthy individuals which are in very minute quantities.

The consumption of these vegetables promotes the health of the individuals protecting them from various degenerative diseases by having the anticarcinogenic substances. Soon level of these vegetables has to be Increased by giving nutritional education to the people.

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DISCUSSION

1. What is the relation between dietary fiber and diabetes?

   Dietary fiber and complex carbohydrates benefit Type I and Type II diabetics. Such diets lower

   1. Insulin requirements
   2. Increase peripheral tissue insulin sensitivity
   3. Decrease serum cholesterol and triglyceride values
   4. Aid in weight control and
   5. Lower B.P.

   Soluble fibers such as pectin, gums, hemi cellular (in fruits) increase intestinal transit time, delay gastric emptying slow glucose absorption and lower serum cholesterol. Insoluble fiber such as cellulose and lignin (vegetables, grains) decrease intestinal transit time, increase faecal bulk, delay glucose absorption and slow starch hydrolysis. Diets high in carbohydrate and fiber improve glucose metabolism without increasing insulin secretion. They lower fasting serum and peripheral insulin concentrations in response to oral glucose administration in both diabetic and nondiabetic individuals.

   High fiber diets promote weight loss. They increase satiety, delay gastric emptying by releasing certain gut hormones. From high fiber foods starch, fatty acids and nitrogen may be less well absorbed. Also high fiber foods take longer to eat.

   Fenugreek seeds, which contain high fiber, are useful to diabetics. It contains mucilaginous fiber and total fiber to the extent of 20 per cent and 50 per cent respectively. In addition, it also contains trigonelline - an alkaloid known to reduce blood sugar level.

2. What is the role of dietary fiber in preventing cancer?

   A. 1. By increasing fecal bulk
      2. By changing bacterial composition in the colon
      3. By binding carcinogens in the bowel
      4. By lowering the fecal pH

5. By inducing structural, functional and chemical changes in the gut mucosa
6. By inhibiting the production of butyric acid
7. By altering bile acid mechanism
8. By accelerating the fecal transit time

3. There are so many major vegetables? Why should we go for minor vegetables?

A. 1. Relatively less costly and nutritious
2. To add variety to our monotonous diet
3. Due to their an assumed way of production
4. There response to basic health needs and
5. We will be having wide range of choices

4. How you classified these minor vegetables?

A. Based on the commercial utilization of vegetables i have classified these vegetables into 3 groups that is

1. Green leafy vegetables
2. Other vegetables and
3. Roots and tubers

5. What are all minor vegetables, which are being grown in KHDP?

A. All most all the minor vegetables like cowpea, pumpkin, coriander, ponnaganni, water leaf, chekkurmanis, curry leaves, aksharakeera, tamarind, mint, clove bean, hyacinth bean, winged bean, bitter gourd etc. are being grown in KHDP.

6. Which vegetable is grown in A.P., which is not being grown in Kerala?

A. Gogu - Roselle - Hibiscus is being grown in Andhra Pradesh. Which is not being grown in Kerala.

7. What is the difference between field bean, hyacinth bean and dolichos bean?

A. The three are synonyms for the same vegetable.

8. Is there any seasonal variation among these vegetables?

A. Yes. In summer the nutritive value of these vegetables is more when compared to other seasons. Because in rainy season because of the water content the nutrients gets diluted and these hyacinth bean and winged bean are the short day plants.

9. Even though Africans are eating dietary fiber in their diet still they are getting colon cancer why?

A. It is due to certain unknown food substances in their diet contains certain toxic alkaloids, which are responsible for colon cancer.

10. In which for Vitamin A is present in vegetables?

A. Vitamin A is present in the form of ß-carotene, which is the precursor of vitamin A and helps in the synthesis of vitamin A in our body.

ABSTRACT

India has made a commendable progress in vegetable production, securing the position of second largest vegetable producer in the world next to China. But the consumption of vegetables is only 210 g/capita/day against the minimum requirement of 285 g/capita/day for a balanced diet. As the dietary pattern in India is changing day-by-day, people wants to change their food habits along with their way of living. In such circumstances a new range of minor tropical vegetables are catching the attention of growers, retailers and consumers (Chaurasia and De, 2001).

Minor tropical vegetables include drumstick leaves; curry leaves, bottle gourd, ridge gourd, dolichos bean, coleus, arrowroot etc. This group of vegetables plays an important role in the diet of human beings by providing vital protective nutrients, which promotes the heath of the individuals (Manay and Shadaksharaswamy, 1987).

Consumption of diet rich in minor tropical vegetables had a decreased risk of cardiovascular diseases, diabetes and cancer due to the presence of some anticarcinogenic substances (Ames *et al.*, 1993).

Even though the vegetables contain some anti-nutritional compounds; the consumption of these vegetables may supply vital nutrients important for human health (Singh and De, 2000).

In order to recognize the potential of under utilized vegetable crops, there is a need to broaden the range of plant species utilized by human being. The untapped potential should be recognized and we should include these vegetables in our daily diet. It is, thus, imperative that required thrusts must be given to the under utilized plants in the national context for exploiting fruitful results in the future.

METHODOLOGIES INVOLVED IN THE ASSESSMENT OF NUTRITIONAL STATUS

By

Jyothi, R.

(2000-16-03)

M.Sc. (Home Science)

SEMINAR REPORT

Submitted in partial fulfillment for the requirement of the course No. Home Science 651, Seminar

DEPARTMENT OF HOME SCIENCE
COLLEGE OF HORTICULTURE
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DECLARATION

I, Jyothi, R. (2000-16-03) hereby declare that seminar entitled "METHODOLOGIES INVOLVED IN THE ASSESSMENT OF NUTRITIONAL STATUS" have been prepared by me, after going through the various references cited here and has not been copied from my fellow students.

Vellanikkara
Date : 5-11-2001

Jyothi, R.
(2000-16-03)

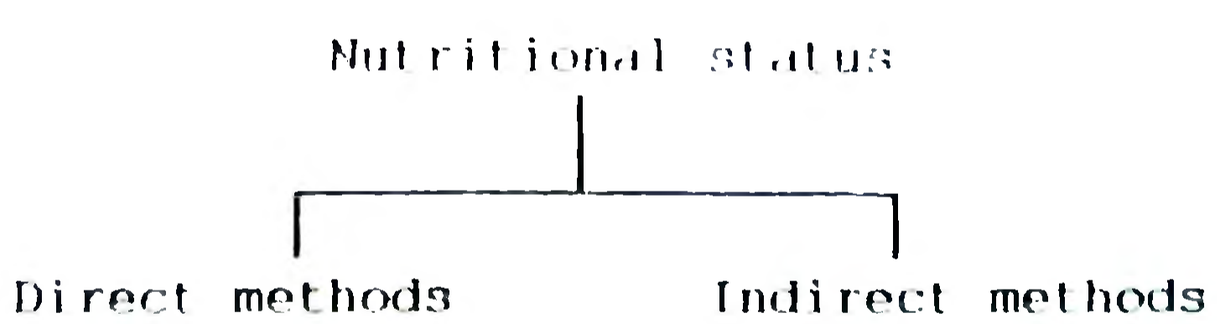
CONTENTS

I. Introduction

India is a developing country where the chance of malnutrition is high. Assessment of nutritional status of community is one of the first step in the formulation of any public health strategy to combat malnutrition. Nutritional status is the condition of the body resulting from the utilization of essential nutrients available to the body. The principle aim of assessment of nutritional status is to determine the type, magnitude and distribution of malnutrition in different geographic areas, to identify the at risk groups and to determine the contributing factors of malnutrition. In addition, factual evidence of the exact magnitude of malnutrition is essential to sensitize administrators and politicians to obtain allocation of materials and human resources and to plan appropriate intervention strategies (Jelliffee, 1966) to overcome the nutritional problems.

Nutritional status may be good, optimum or poor depending on the intake of dietary essentials, relative need for nutrients as well as body's ability to utilize the different nutrients (Bamji, 1996).

II. Methods of assessing nutritional status



Anthropometric measurement	Vital statistics like
Diet survey	Mortality rate
Clinical examination	Morbidity rate
Biochemical examination	Fertility rate
Biophysical and Radiological examinations	

A. Direct methods

i. Anthropometric measurements

Anthropometry has been accepted as an important tool for the assessment of nutritional status. It is the measurement of human body at various ages and levels of nutritional status. According to Vijayaraghavan (1987) and Sharma and Kalia (1990) anthropometric measurement is a simple, useful, practical index of nutritional status and has been widely used to assess the nutritional status.

The most commonly used measurements in routine surveys are

a) Body weight
b) Crown heal length or standing height
c) Mid-upper arm circumference
d) Fat fold at triceps
e) Circumference of head and chest

Body weight

Body weight is the most widely used and simplest reproducible anthropometric measurement, for the

evaluation of nutritional status of young children (Swaminathan, 1987, Rao and Vijayaraghavan, 1996). Body weight indicates the body mass and is a composite of all body constituents like water, minerals, fat, protein, bone etc. Changes in the nutritional status can be measured by serial measurement of weight rather than a single measurement at a point of time. Salter scale is used for infants and personnel platform weighing balance is used for adults for measuring the body weight. Comparison of weight for age values with regional standards at corresponding ages would help to determine the degree of under weight in a community (Gopaldas and Seshadri, 1987).

According to Rao and Vijayaraghavan (1996) body weight is very sensitive even to small changes in the nutritional status. After measuring the body weight it should be compared with the reference regional standards to know the type of malnutrition.

Reference standards

Anthropometric measurements obtained on well to do children of elite parents are usually treated as reference standards.

WHO (1983) suggested following criteria for the reference standards

a) Measurements should relate to a well nourished population
b) The sample should include at least 200 children in each age and sex

c) The sample should be of cross sectional in nature

d) Measurements should be carefully made

e) Measurements should be recorded by trained observers

In India Vijayaraghavan *et al.* (1974) and Ghosh *et al.* (1977) collected some anthropometric data on large number of well to do children attending public schools catering to elite segments of the population. The measurements of British children reported by Tanner *et al.* (1966) those of Dutch children reported by Wieringer (1972) those of American children reported by NCHS (Hamill *et al.*, 1979) are the useful international reference standards.

After comparing the weight with standard reference weight the subjects can be classified into different degrees of malnutrition. The important classifications to group the subjects based on weight for age suggested by Gomez *et al.*, 1956) and Indian Academy of Paediatrics (1972).

Gomez classification

≤ 60% weight for age	: Grade III malnutrition
61-75% weight for age	: Grade II malnutrition
76-90% weight for age	: Grade I malnutrition
> 90% weight for age	: Normal

The weight of age classification is age dependent and it will give the index of current nutritional status of the individual.

Height

Height deficit is an indicator of long term potential malnutrition. The extend of height deficit in relation to age as compared to regional standards could be regarded as a measure of malnutrition (Gopaldas and Seshadri, 1987). Among the environmental factors which influence the height of an individual nutrition and morbidity are very important because inadequate dietary intake and or infections reduce the nutrient availability at cellular level leading to growth retardation and stunting (Rao and Vijayaraghavan, 1996). To measure the height of children below the age of 2 years who cannot stand properly, the recumbent length called crown heal length should be measured with an infantometer. In older children and adult height is measured with a vertical measuring rod called anthropometer.

The measured height can also be compared with reference standard and grouped on the basis of the classification suggested by Rao (1976).

Height for age classification by Rao (1976)

< 80% of the standard	: Poor
80-90% of the standard	: Mild retardation
91-100% of the standard	: Normal

This classification will give an index of past nutritional status of individual. Both height for age and weight for age classification are age dependent. Most often accurate assessment of age may not be possible. Weight for height is believed to be age independent. It is also shown to be a good prognostic indicator

particularly in severe malnutrition and has often been considered as a good index of current nutritional status. This can be compared with standard reference and the results can be interpreted on the basis of the classification suggested by Waterlow (1972).

Weight for height classification (Waterlow, 1972)

< 75% weight for height	: Severe malnutrition
75-84% weight for height	: Moderate
85-90% weight for height	: Marginal malnutrition
> 90% weight for height	: Normal

This weight for height classification will give an index of present and past nutritional status of the individual. If we want to assess the duration of malnutrition we can use another classification by Seoane and Latham (1971). This classification is based on weight for age, height for age and weight for height.

Nutritional status	Height for age	Weight for age	Weight for height
Normal	Normal	Normal	Normal
Past chronic malnutrition	Low	Low	Normal
Current short duration malnutrition	Normal	Low	Low
Current long duration malnutrition	Low	Low	Low

While evaluating the usefulness of anthropometric measurements such as height and weight, Seoane and Latham classification was found to be better as compared to Sastry and Vijayaraghavan (1973).

Body Mass Index

The ratio of weight/height^2 referred to as Body mass index (BMI) provides a reasonable indication of the nutritional status of adults especially the chronic energy deficiency in adults. The BMI has a good correlation with fatness. It may also be used as an indicator of health risk. The following classification suggested by James *et al.* (1998) can be used to assess the chronic energy deficiency in adults.

BMI class	Presumptive diagnosis
< 16.0	Chronic energy deficiency Grade III severe
16.0-17.0	Chronic energy deficiency Grade II moderate
17.0-18.5	Chronic energy deficiency Grade I mild
18.5-20.0	Low weight - normal
20.0-25.5	Normal
25.0-30.0	Obese Grade I

Thus, BMI < 18.5 indicates under nutrition and >20.0 is considered as an indicator of obesity.

In India, like other developing countries prevalence rates of over weight and obesity are high. For the assessment of the degree of obesity anthropometric indices like weight for height (%) and weight/height^2 are useful.

In some countries like Czechoslovakia, Brokas formula, stating that "Height in cm - 100 = ideal weight" has been utilized for the assessment of nutritional status in adults. Actual weight of the individuals were

expressed in percentage of the ideal weight based on Broka's formula.

Weight for height (%)

< 80	: Under nutrition
80-120	: Normal
120-130	: Overweight
> 130	: Obese

Mid upper arm circumference

MUAC is an indicator of muscle development and reflects protein calorie malnutrition of early child hood (Jelliffe, 1966 and Kamath, 1986). It is considered simple, useful and more feasible method to assess the nutritional status of children (Voorhoea, 1983 and Rao and Vijayaraghavan, 1996). Ordinary fibre glass is used to assess the circumference. The mid upper arm circumference is taken on the left hand (in right handed people) mid way between the tip of the shoulder (acromium) and the tip of the elbow (olecranon).

Mid upper arm circumference classification among preschool children

< 12.5 cm	: Severe malnutrition
12.5-13.5	: Moderate malnutrition
> 13.5	: Normal

Head and chest circumference

Head circumference relates mainly to size of the brain which increases rapidly during infancy. The chest In a normally nourished child grows faster than the head

during the second and third year of life. In a malnourished state due to the poor growth of the chest, the head circumference may remain greater than the chest (Rao and Vijayaraghavan, 1996). A flexible fibre glass tape is used to measure the head and chest circumference. If the head and chest circumference ratio (for children above 6 months of age).

< 1 : Normal

≥ 1 : Malnourished

Skin fold thickness

This method is applicable to all age groups. It will indicate the present under and over nutrition. Measure the body composition obesity on adults and skin fold thickness with help of skin fold caliper or harpender caliper. It is expensive and difficult to conduct in field.

The classification based on skin fold triceps. If the SFT is

< 60%	: Severe malnutrition
60-80%	: Moderate malnutrition
80-90%	: Mild malnutrition
90-110%	: Normal

Thus, anthropometry can be used to assess the type, extend and duration of malnutrition in a community. Anthropometry is relatively efficient to detect individuals at high risk of morbidity associated with malnutrition. However there is still a debate as to which of the anthropometric parameters is the best and simplest.

ii. Diet survey

Diet is a vital determinant of health and nutritional status of people. Diet surveys constitute an essential part of any complete study of nutritional status of individuals or groups and provide essential information on nutrient intake levels, sources of nutrition, food habits and attitudes (Gopaldas and Seshadri, 1987).

Diet survey include

1) Food balance sheet method
2) Inventory method
3) Weighment method
4) Expenditure pattern method
5) Diet and history
6) Oral questionnaire method (24 hour recall method)
7) Duplicate sample
8) Dietary score method
9) Recording method

a. Food balance sheet method

This method is employed when the information regarding the availability of food is needed at macro level - country, region etc. i.e. is at the national level.

Percapita availability per day (g)

= stocks at the beginning of the year + total food produced + imports - stocks at the end of the year + exports + seeds + cattle/poultry feeds + wastage + Mid year population x 365 days.

The data from FBS thus tells us the food available at country or regional level but not the food actually consumed by the people. In this method there is no way of assessing the wastage of food that takes place from retail level to consumption level and no allowance is made for inedible portion of food which is discarded. They are of little use in health and nutrition workers but essential for policy makers and administrators.

b. Inventory method

This method is often employed in institutions like hostels, armybarracks, orphanages, old age homes etc where homogeneous groups of people take their meals from a common kitchen. Here, a record related to the amount of food used in the kitchen should maintained and the average intake of person per day is calculated as follows

Stocks at the beginning of the week - stocks at the end of the week + total number of inmates partaking the meal x No. of days of survey.

This method like the FBS method provides an estimate of the food available rather than the food actually consumed. lapses in recording the "issues and receips" adversely affect the computations. This method is possible only when the community is fairly educated.

c. Weighment method

In this methods foods are actually, weighed by using an accurate balance. This method is used for weighing raw and cooked foods. Weighment method of diet

survey according to Gore *et al.* (1977) could have accurate values of dietary intake. According to Swaminathan *et al.* (1967) and Thimmayamma and Rao (1996). It is ideal to conduct the survey for seven consecutive days to capture a true picture of the diet. However Rao (1975) states that any single day or two day weighment method would be as efficient a tool as that of 7 days.

Calculation procedure for weighment method

$$\text{Individual intake in terms of raw equivalent} = \frac{\text{Total raw amount of each ingredient (g)}}{\text{Total cooked amount (g)}} \times \text{individual intake of cooked amount (g)}$$

This method is time consuming and needs co-operation of the housewives throughout the study period. This method will give an idea about accurate amount of food consumed by individual.

d. Oral questionnaire method (24 hour recall method)

In this method a set of standardized cups suited to local conditions are used. Here, respondents are asked about the food he had eaten in the previous day. By this method we will get an idea about the preparation he had made for breakfast, lunch, tea and dinner and the amount of raw ingredients used for each preparation. The cooked foods are weighed by standard cups. The calculation procedure of oral questionnaire method is similar to that of weighment method. A thorough knowledge of local measures and the method of preparation should be gathered by the investigators for obtaining a realistic picture of

the food consumed. By this method we will get the accurate amount of food consumed by individual.

e. Expenditure pattern method

In this method money spent on food as well as non food items is assessed by administrating a specially designed questionnaire. The reference period may be one month. This methods avoids actual weighing of foods, needs more time as additional data on price of individual food items and qualitative aspects of diet becomes necessary for obtaining a realistic picture of community.

f. Diet history

This method is useful for obtaining qualitative details of diet and studying patterns of food consumption at household or industrial level. The procedure includes assessment of the frequency of consumption of different foods, daily or number of times in a week or fortnight or occasionally. This method has been used to study (i) Meal pattern (ii) dietary habits (iii) peoples food "preferences" and "avoidances". Physiopathological conditions like pregnancy, lactation and sickness etc.

g. Duplicate sample

In this method the individual is referred to save a duplicate sample of each type of food eaten by him during the day. These samples are then collected and analysed in the laboratory for the chemical constituents. It is the most accurate method but is costly and needs a good laboratory support (Bamji, 1996).

h. Dietary score

This method involves assigning an arbitary score to the foods on the basis of its nutrient content. The frequency of consumption of foods and the total score and percentages are calculated. The values of this qualitative assessment method is enhanced when it is combined with quantitative method of survey and nutritional status assessment (Bamji, 1996).

i. Recording method

It involves the maintenance of dietary, records of weighed quantities of foods consumed by an individual or family according to number of days of survey. In this method large sample can be covered in a short time (Bamji, 1996).

Even the best of diet surveys give only an approximate estimate of foods and nutrients consumed but not the amount absorbed or utilized.

iii. BIOCHEMICAL

Biochemical measurement represents the most objective assessment of the nutritional status of an individual frequently providing pre or subclinical information. There are several biochemical indicators of malnutrition specific for different nutritional deficiencies. In most instances nutrient intake are reflected in their levels present in blood/serum or urine. Biochemical changes will proceed the clinical

symptoms. So that they may be used as early indicators of malnutrition (Bamji, 1996).

In biochemical method we usually measure the amount of nutrients present in blood and urine, amount of abnormal metabolite, changes in the activity of enzyme and changes in the blood component.

Discussed below are the biochemical indicators for certain nutritional disease commonly seen in our country. Protein energy malnutrition (Gopaldas and Seshadri, 1987)

Nutritional deficiency	Indicator	Age	Serum Albumin level g/100 ml	Inference
Protein energy malnutrition	Serum albumin and serum transferrin	1-5 years	< 2.8 < 3 > 3	High risk Medium risk Low risk

Vitamin A deficiency (Gopaldas and Seshadri, 1987)

Evaluation of serum vitamin A levels

Measurement index	Less than acceptable (at risk)		Acceptable (low risk)
	Deficient (high risk)	Low (medium risk)	
Plasma retinol (mcg/dl) (all ages)	< 10	10-19	> 20
Plasma carotene	-	20-39	> 40

Anaemia

WHO criteria for the diagnosis of Anaemia

Determination	Levels of considered Aanemic or iron deficient
Hb (g/d/venous blood)	
Children aged 6 months to 6 years	< 11
Children aged 6 to 14 years	< 12
Adult males	< 13
Adult females - non pregnant	< 12
Adult females - pregnant	< 11
Serum iron adults (mcg/100 ml)	< 50
Transferrin saturation (%) Adults	< 15

iv. CLINICAL EXAMINATION

Clinical examination is an important practical method for assessing the nutritional status of community. The method for clinical examination is usually based on examination for changes, believed to be a related to inadequate nutrition, that can be seen or felt in superficial epithetical tissues, especially the skin, eyes, hair and buccal mucosa, or in organs near the surface of the body such as parotid and thyroid gland. Clinical examination of a community can give valuable information to the public health worker, especially in regions of the world where malnutrition is wide spread (Bamji, 1996).

According to the report of the WHO Export committee on Medical Assessment of Nutritional Status, the signs and symptoms that are considered to be of value in nutritional assessment and recorded on follows.

	Signs known to be of value in nutrition surveys
Hair	- Lack of lustre - Thinness and sparseness - Straightness - Flag sign - Dyspigmentation
Face	- Diffuse dyspigmentation - Naso-labial dyssebacea - Moon face
Eyes	- Pale conjunctiva - Bitot spot - Conjunctival xerosis - Corneal xerosis - Keratomalacia
Nails	- Koilonychia
Skin	- Xerosis - Follicular hyperkeratosis - Pellagrous dermatosis - Flaky pain dermatosis

Various non nutritional environmental influences may be responsible for identical appearances. Further most signs of malnutrition are not specific to lack of one nutrient and can often be produced by various non nutritional factors. The interpretation of clinical signs can be best made by using a 'grouping of sings' which have been commonly form a pattern as associated with deficiency of a particular nutrients.

The following section discuss is the grouping of clinical signs and their interpretation with respect to

certain nutritional deficiency diseases (Gopaldas and Seshadri, 1987).

Nutritional deficiency	Clinical symptom
Protein calorie malnutrition	Oedema Dyspigmentation of the hair Thin sparse hair Muscle wasting Moon face Hepatomegaly
Vitamin A deficiency	Bitots spot Conjunctival xerosis Corneal xerosis Kerato malacia Follicular hyperkeratosis
Iron deficiency	Pale conjunctiva Koilonychia Atrophic lingual Papillae

v. Biophysical and Radiological examinations

In specific studies where we require additional informations like changes in bone or in muscular and physical performance like in beriberi, rickets etc., these methods can be used. In routine studies they are not used.

Among the direct methods clinical examination and nutritional anthropometry are commonly used in routine surveys, since they are relatively simple, specific and sensitive in community situations and do not call for

sophisticated equipment. No single method can produce a complete picture of nutritional status. So we have to use a combination of methods depending upon the objective of the study and the resources available.

B. INDIRECT METHOD

In indirect method we measure the vital statistics like, mortality rate, morbidity rate and fertility rate (Gopaldas and Seshadri, 1987).

i. Mortality rate

Death rate is defined as number of deaths per 1000 estimated mid-year population in one year.

$$\text{Death rate} = \frac{\text{Number of deaths during the year}}{\text{Mid year population}} \times 1000$$

ii. Maternal Mortality rate (MMR): It is the number of deaths from puerperal causes per 1,000 live births.

iii. Infant mortality rate (IMR): It is the number of infant deaths under one year of age per 1000 live births in any population in one year.

iv. Still birth: It is the foetal deaths occurring after 28 completed weeks of gestation.

Conclusion

Like this various indirect measures like incidence rate, prevalence rate, under birth rate etc. can be used indirect parameters of nutritional status.

All measures of nutritional status have certain advantages. They serve as short hand indicators of health, welfare and survival of individuals of communities. Most of the measures are quite cheap. It is easier to collect information with respect to these measures than on other indices like poverty level of housing or sanitation and hygiene. But all measures have their limitations too. Indications have to be selected in relation to the system to be studied. The criteria involved in selection of the parameters for monitoring and evaluation in nutrition are specificity, sensitivity, simplicity and economy.

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DISCUSSION

1. What is the reason for less malnutrition incidence in Kerala compared to other states?

   Nutritional surveys revealed that the diets consumed by a large majority of the population in Kerala consist predominantly cereals and pulses. Consumption of vegetables, egg, milk, meat, fish are high in Kerala compared to other states. So in Kerala malnutrition is less compared to other states.

2. How will you eliminate the genetic factors which influence the height of the individual?

   Height of an individual is influenced by both genetic and environmental factors. While measuring nutritional status in terms of parameters like height and weight, after taking the measurement it should compare with the standards. For every age there is particular standards for height and weight. By comparing the measurement with the standards we can eliminate the genetic factors.

3. What are the common symptoms seen in children due to iodine deficiency?

   In children severe iodine deficiency leads to cretinism. Mental retardation stunted growth are the symptoms of cretinism.

4. What is the present infant mortality rate in India?

   72 per 1000 live births.

5. In iodine deficiency whether the BMR increases or decreases?

   In iodine deficiency BMR increases.

6. Unto what level BMR increases?

   BMR increases upto 100%.

7. Protein calorie malnutrition is commonly seen in which states of India?

   In our country the commonly seen nutritional deficiency are protein energy malnutrition, anaemia, vitamin A deficiency and iodine deficiency. Protein calorie malnutrition is commonly seen in rural areas of Andra Pradesh, Bihar, Maharashtra, Karnataka, West Bengal, Kerala.

8. What do you mean by Keratomalacia

   Ulceration of the cornea.

9. What are the commonly seen nutritional deficiencies in our country? In Kerala?

   Protein energy malnutrition, vitamin A deficiency and anaemia are commonly seen in our state Kerala.

ABSTRACT

India is a developing country where a considerable portion of population is living below the poverty line. Hence, chances of malnutrition are very high. Assessment of nutritional status of the community is one of the first step in the formulation of any public health strategy to combat malnutrition.

Nutritional status is the condition of the body resulting from the utilization of essential nutrients available to the body. The principle aim of assessment of nutritional status is to determine the type, magnitude and distribution of malnutrition in different geographic areas, to identify the at risk groups and to determine the contributory factors of malnutrition. In addition, factual evidence of the exact magnitude of malnutrition is essential to sensitize administrators and politicians to obtain allocation of materials and human resources and to plan appropriate intervention strategies to improve the nutritional status (Jelliffee, 1966).

Nutritional status can be assessed either by direct or indirect methods. The direct methods include the anthropometric measurements, dietary surveys, biochemical methods, clinical examination and biophysical and radiological methods (Gopaldas and Seshadri, 1987; Vijayaraghavan, 1987; Sharma and Kalia, 1990; Bamji, 1996; Thimmayamma and Rau, 1996). A variety of vital statistics like infant and childhood mortality rates, maternal mortality rates etc. have been considered as indirect indicators of nutritional status.

All measures of nutritional status have certain advantages and limitations. The methods to be selected for the assessment of nutritional status should be simple, sensitive, specific and economical. Instead of a single method a combination of different methods can be used to evaluate the nutritional status of a community.

NUTRIENT LOSS DURING PRESERVATION AND STORAGE OF MAJOR FRUIT PRODUCTS

By

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(2000-16-05)

M.Sc. (Home Science)

SEMINAR REPORT

Submitted in partial fulfillment for the requirement of the course No. Home Science 651, Seminar

DEPARTMENT OF HOME SCIENCE
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DECLARATION

I, Teena Joy (2000-16-05) hereby declare that this seminar entitled "NUTRIENT LOSS DURING PRESERVATION AND STORAGE OF MAJOR FRUIT PRODUCTS" have been prepared by me, after going through the various references cited here and has not been copied from my fellow students.

Vellanikkara
Date :5-11-2001

Teena Joy
(2000-16-05)

CONTENTS

Nutrient loss during preservation and storage of major fruit products

I. Introduction

Fruits are undoubtedly man's oldest food. In India the cultivation of fruits dates back to ancient times (Singh, 1969). India is endowed with varied agro-climatic conditions which offer immense scope for the cultivation of various kinds of horticultural crops. This provides an excellent platform for the country to emerge as a leading producer of horticultural crops (Reddy, 2000). India now ranks number one in world fruit production with a share of 42.17 million tonnes (Chadha, 1999). Sethi (1993) has stated that 20-30% of the fruit produced in this country are not utilized due to post harvest problems and hardly 1% of the total produce is being utilized for processing. Therefore to minimise post harvest losses and to obtain better returns there is dire need for exploring the possibilities of utilising fruits in the processing industry (Khurdiya and Roy, 1985). The fruit processing industry has been declared as a thrust area and is now a potential earner of foreign exchange through export of processed fruit products (Kapoor, 1993).

Poornia *et al.* (1994) is also of the view that fruit processing helps to solve the problems of under employment during off-season in Agriculture sector besides it ensures fair returns to the growers and improves their economic conditions. Besides these advantages, the fruit processing has certain disadvantages. Considerable nutrient loss occurs during preservation and storage of fruits, which have to be

given special attention. In this context I am going to deal with the topic 'Nutrient loss during preservation and storage of major fruit products'.

Fruits in human nutrition make balance diet which leads to the development of sound health and happiness of human beings. Fruits provide vitamins and minerals and therefore are considered as 'protective food' (Singh, 1995). Water is the chief constituent of fruits. About 75 to 95 per cent of the total weight is from water. Fruits as a whole are rich sources of vitamin C and ß carotene - provitamin A. The ascorbic acid content varies widely from 2-700 mg/100 g. Citrus fruits are good sources while guava, cashew fruit, lime, mango, papaya and orange are other sources of vitamin C. ß-carotene can be obtained from fruits like mango, papaya, jack fruit, dates etc. (Begum, 1991).

The B vitamins occur in relatively low concentration in fruits. Minerals are not particularly high in fruits. However calcium, phosphorus, iron, potassium are found in many fruits. Calcium is obtained from fruits like citrus, guava, dates, sapota and grapes. Fruits like avocado, dates, pomegranate, raisins etc. are rich sources of phosphorus. Iron can be supplied by dates, guava, grapes, sapota, plum etc. Potassium represent 1% of the fresh weight of the fruits (Singh, 1995). Fruits are a good source of energy because many of them contain digestible form of carbohydrates like sugar or starch. The important sugars present in fruits are glucose, fructose and sucrose (Duckworth, 1966). The

polysaccharides cellulose, hemicellulose and pectic substances are the structural components of fruits. These make fruits important sources of roughage or bulk in the diet (Manay and Shadaksharaswamy, 1987). Most of the fruits contain small amount of pectin. Some examples guava, apple contains appreciable amounts of pectin (Swaminathan, 1988). Characteristic flavors of fruits are due to the presence of organic acids in them. Malic and Citric acids occur in most of the fruits, but tartaric acid is a prominent constituent of grapes oxalic acid is also present (Begum, 1991). Proteins represents less than 1% of fresh weight of fruits. Fruits are poor source of fat. Avocado is an exception containing 25% fat (Sri Lakshmi, 1997).

Nutritive value of major fruits (per 100 g)

Name of Fruit	Moisture (g)	Energy (Kcal)	Calcium (mg)	Phosph-orus (mg)	Iron (mg)	Carotene (mg)	B vitamins (mg)	Ascorbic acid (mg)
Apple	84 6	59	10	14	1 0	0	-	1
Banana	70 1	116	17	36	0 9	78	0 63	7
Cashew fruit	86 3	51	10	10	0 2	23	0 47	180
Grapes	82 2	58	20	23	0 5	3	0 31	1
Lemon	85 0	57	70	10	2 3	0	0 13	39
Guava	81 7	51	10	28	1 4	0	0 46	212
Mango	81 0	74	14	16	1 3	2743	1 07	16
Pineapple	87 8	46	20	9	1 2	18	0 42	39

Gopalan *et al.*, 1982

The nutritional contribution of fruits compared to total food supply is given below.

Ascorbic acid	- 90%	Magnesium	- 25%
Vitamin A	- 50%	Iron	- 20%
Vitamin B1	- 20%	Calories	- 10%
Niacin	- 20%	Proteins	- 7%
Potassium	- 10%	Fat	- 1%

(Ratnatunga *et al.*, 1978)

Much of the vitamins and minerals needed for human body is obtained from fresh fruits. But these fruits are highly perishable. To reduce wastage and to make it available through out the year, the fruits should be processed into value added products (Khurdiya and Roy, 1985).

II. Methods of fruit preservation - physical and chemical methods

Various fruit processing/preservation methods are present. These methods are broadly classified by Girdharilal *et al.* (1986) and are presented below:

I. Physical methods	
a) Thermal processing	Canning, pasteurisation
b) Storage at low temperature	Freezing
c) Removal of water	Sundrying, Dehydration
d) Irradiation	Application of UV or ionizing radiation
II. Chemical methods:	
a) By salting or brining	Pickling
b) By addition of sugar and heating	Fruit preserves, jams, jellies, marmalades, candies etc.
c) By addition of chemical preservatives sodium benzoate, potassium metabisulphite	Squashes, cordials
d) Fermentation	Fruit wines

Source: Girdharilal *et al.* (1986)

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c) By addition of chemical preservatives sodium benzoate, potassium metabisulphite	Squashes, cordials
d) Fermentation	Fruit wines

Source: Girdharilal *et al.* (1986)

Preservation by application of heat is a most common method. It is generally known as preservation by canning or heat processing in sealed containers made of tin, plate or glass or more recently of heat resistant plastic materials (Girdharilal *et al.*, 1986).

Preservation by freezing is a method of increasing the storage life of fresh fruits. But it is being employed to a limited extend in the case of some fruits such as peach, pear etc.

Another important method of preservation is drying or dehydration. Sundrying is extensively employed in many parts of the world to dry a variety of fruits.

Preservation of fruits by application of U.V. or ionizing radiation is another method. There is considerable interest in this technique, especially in view of the fact that cheap sources of irradiation have become freely available as a result of development of atomic energy installations in some parts of the world (Girdharilal *et al.*, 1986).

Preservation by salting or brining of unripe fruits such as mango, lime, lemon etc. is also well known. Preservation by addition of sugar and application of heat is a highly important method in the case of fruits which are utilized in a very large quantities to make jams, jellies, marmalades and preserves. This method is simple, cheap and easy to adopt and hence its universal popularity. The use of chemical additives, which are permitted as harmless, within limits is fairly

widespread in the case of a variety of squashes, cordials and other beverages. At present, only sulphur dioxide and benzoic acid and its salts are permitted in fruit products. Preservation by fermentation is a very ancient and well known method. Yeast fermented fruit wines, which contain ethyl alcohol as a natural preservative have been prepared (Girdharilal *et al.*, 1986).

The adoption of above said preservation methods aims not only in the suppression of spoilage organisms and preservation, but retention of the nutritive value of the fresh fruit in the processed product is also equally important. Processing involves many operations - washing, trimming, peeling, blanching, thermal processing, dehydration, packing, storage etc. and at each stage there is a likelihood of available nutrients being lost. The common belief is that the final product is depleted in most of the nutritive constituents present in fresh food. But with advances in processing methods, processed foods are not very inferior to fresh foods and are not in any way less nutritious than foods cooked in the normal way (Ratnatunga *et al.*, 1978).

Modern methods of preservation of fruits are carried out so as to minimize the destruction of vitamins and minerals in them (Girdharilal *et al.*, 1986). Though vitamins and minerals are considered as micronutrients present in low quantities they have macro health implications. The daily intake of vitamins recommended by ICMR is given below.

Indian recommended daily intake of some vitamins

	Retinol (µg)	Thiamine (mg)	Riboflavin (mg.)	Niacin (mg)	Vit. B-12 (µg)	Ascorbic acid (mg)
Infants (0-12 months)	400	-	-	-	0.20	30
Children (1-12 years)	250-600	0.6-1.0	0.7-1.2	8.0-14.0	0.5-1.0	30-50
Boys Girls (13-19 years)	750 750	1.3-1.5 1.1	1.4-1.7 1.2	17-21 14	0.5-1.0	30-50
Adults Men Women	 750 750	 1.2-2.0 1.0-1.5	 1.3-2.2 1.0-1.7	 16-26 13-20	 1.0	 50

(NIN, 1984)
(ICMR, 1984)

These vitamins, which are required for proper growth and good health, undergo changes under the influence of heat, oxygen, pH etc. The following table shows the stability of vitamins under environmental changes.

Vitamin	Heat	Light	Air	pH-7	pH >7	pH <7
Thiamin	L	S	L	S	L	S
Riboflavin	L	L	S	S	L	S
Pyridoxine	S	L	S	S	S	S
Niacin	S	S	S	S	S	S
Ascorbic acid	L	L	L	S	L	S
Carotenes (Pro. Vit-A)	L	L	L	S	S	L

L - Loss; S - Stable

It can be seen that heat adversely affects all except pyridoxine and niacin. Thermal destruction is the most important factor of nutrient loss. The fat soluble vitamins (Vitamin A) are relatively heat stable in the absence of oxygen but appreciable losses occur when heated in the presence of oxygen. Prolonged heating leads to complete destruction. Among the water soluble vitamins, thiamine is very heat sensitive especially in

alkaline medium. Riboflavin is very light sensitive and vitamin C is easily oxidised in the presence of air. The loss of water soluble vitamins ranges from 0 to 60 per cent as a result of leaching and thermal destruction. Vitamin A (Carotene) are water insoluble and as such are not lost as a result of leaching and their destruction due to oxidation is slight. Frying and roasting cause their loss upto 40-60% (Salunkhe *et al.*, 1991).

The loss due to processing may be due to trimming. The removal of skins and peels of fruits result in loss of vitamins and minerals due to unequal distribution of nutrients in the food stuff. Washing with water will leach out appreciable quantities of water soluble nutrients from fruits (Ratnatunga *et al.*, 1978).

Carbohydrate is present in fruit in the form of sugars. Leaching of the sugar takes place during blanching. Blanching causes decrease in the protein content (Salunkhe *et al.*, 1991).

III. Nutrient loss in physical methods

Canning

Canning as a means of food preservation was developed by Nicholas Appert. It involves the following steps.

1. Washing
2. Sorting/Grading
3. Blanching
4. Peeling/slicing/coring
5. Filling/exhausting/sealing
6. Retorting/cooling

Washing : Washing reduces the load of spoilage bacteria that is on the product, thus increasing the effectiveness of the sterilization process. There is essentially no loss of nutrients by this process (Salunkhe *et al.*, 1991).

Sorting/Grading : In sorting and grading, inferior and damaged products are removed. There is no nutrient loss.

Blanching : Blanching consist of heating the product to a high enough temperature to accomplish the desired effect. This step is usually associated with vegetable processing (Ratnatunga *et al.*, 1978).

Peeling/slicing/coring : Some fruits such as peaches, apples, pears etc. require peeling before canning peeling methods can cause nutrient loss in products. Peeling can be done with hot water, hot NaOH solutions and mechanical peelers. Nutrient loss can occur from leaching out water soluble constituents or degrading heat sensitive compounds. The least change in the nutrient composition of the final produce would be in the mechanical peeling.

Filling/exhausting/sealing : Metal cans and glass bottles are used for canning. After the product is filled into the container, it usually passes through steam before sealing to reduce oxygen in the can head space. Oxygen in the head space could lead to oxidative changes in the product. The oxidizing of ascorbic acid during processing is minimized by eliminating as much oxygen as possible from the can head space, but still about a third is lost in the canning of products (Salunkhe *et al.*, 1991). The

filling and sealing operation is carried out under sterile conditions (Salunkhe *et al.*, 1991).

Retorting/cooling : In retorting, the sealed container is immersed in hot or boiling water or exposed to steam under pressure. The heat that the product is submitted to during retorting can cause a loss in heat sensitive nutrients. Vitamins such as thiamine and riboflavin are sensitive to heat in higher pH products. Thiamine degradation accelerated by higher temperatures and longer times (Bendex *et al.*, 1951). Thiamine is retained in acid products such as tomatoes, because of the short processing time that is used. ß-carotene is degraded during the canning operation. As the canning involves destruction of nutrients a modification of this process has been developed. It is high temperature short time method (HTST). This process appears to be less destructive to heat labile vitamins than the low temperature long time process.

Several studies have been done to find out the changes in the nutrients during canning process. Pruthi *et al.* (1954) have studied the effect of processing operations on the nutritive value of canned mango and reported that the retention of carotene and ascorbic acid, immediately after processing was very high and of the order of about 98 and 90 per cent respectively. A comparative study was done by Doreyappa Gowda and Ramanjaneya (1995) on the chemical composition of fresh mango pulp and canned juice.

It is given in the following table.

Composition	Mango fresh pulp	Mango canned juice
T.S.S.°B	19.0	20.8
pH	4.4	3.6
Acidity %	0.4	0.5
Reducing sugar %	4.6	6.9
Carotenoids mg/100g	11.5	5.1
Vitamin C mg/100 g	51.4	13.1

Pasteurization

When foods are heated in containers or by other methods to a temperature below the boiling point of water for a definite period, the process is known as pasteurization. It is employed in the case of beer, wines, fruit juices and certain other foods to increase shelf life (Manay and Shadaksharaswamy, 1987).

Chemical changes during pasteurisation of mango pulp

Treatment	Chemical changes			
	Carotene (mg/100 g)	Vit. C (mg/100 g)	T.S. (%)	R.S. (%)
Pasteurisation	Reduced by 84%	Reduced by 53%	Increased from 10.8 to 11.8	Increased from 4.1 to 6.9

Freezing

In 1905, the first commercial freezing operation for processing fruits was established. Fruits to be frozen are harvested, and then transported to the processing plant, where they are frozen first and then packaged. Granular sugar or syrup is usually added to the

packaged fruit to retard oxidative reactions and increase product quality. Losses of oxygen sensitive nutrients such as vitamin C can occur during frozen storage if the fruit is not packed in syrup (Salunkhe *et al.*, 1991). Freezing as such does not injure vitamins. It is the mishandling both before and after freezing which lowers the vitamin content compared to that of the raw material. Freezing is the better method to preserve the nutritional value of fruits as compared to other preservation methods. But the disadvantage is that it is quite expensive (George, 1993).

Dehydration

Dehydration means removal of water from the food by heat. Dehydrated fruits and their products are good sources of energy, minerals and vitamins. Dehydrated fruits are concentrated in nutrients (Salunkhe *et al.*, 1991). Dehydrated fruits are fairly rich sources of minerals.

Fruit	Treatment	Ca (mg)	Fe (mg)	P (mg)
Banana	1) Fresh	75	1.05	88.0
	2) Sulphured and dried	190	1.45	80.0
Papaya	1) Fresh	190	0.08	41.5
	2) Sulphured and dried	210	0.06	50.5
Pineapple	1) Fresh	360	-	46.6
	2) Sulphured and dried	570	-	45.3

(Salunkhe *et al.*, 1991)

However, during the process of dehydration some vitamin potency may be lost. Vitamin A and C are sensitive to oxidative degradation (Salunkhe *et al.*, 1991). The loss of oxygen sensitive vitamins A and C can

be minimised by sulphuring as sulphur dioxide is a strong reducing agent and minimizes their loss during processing (Salunkhe *et al.*, 1991). The retention of ß-carotene in some sulphured and dehydrated fruits are given in the table. Beta-carotene is fairly stable and reasonably well retained.

Dehydrated papaya and mango are good sources of ß-carotene

Fruit	Treatment	ß-carotene	
		Mg/100 g	% retention
Papaya	1) Fresh	37,070	-
	2) Sulphured and dried	26,290	70.6
Mango	1) Fresh	29,440	-
	2) Sulphured and dried	14,910	50.6

(Ratnatunga *et al.*, 1978)

Thiamine can be destroyed by heat and sulfuring and riboflavin is light sensitive. Fruits can be sundried, dehydrated or processed by a combination of these methods. Sundrying causes large losses in carotene and ascorbic acid. Rapid drying retains greater amounts of ascorbic acid than does slow drying. Dehydration reduces these losses (Salunkhe *et al.*, 1991).

Several studies have been done to find out the changes in the nutrients during dehydration. Cherian (1998) studied the development of papaya based blended products. Papaya leather was prepared and its chemical composition was compared with fresh papaya fruit.

Chemical composition of papaya fruit and papaya leather - A comparison

Parameters	Fruit	Leather
pH	6.28	4.41
T.S.S. (°B)	10.50	65.10
Acidity (%)	0.23	0.34
Reducing sugars (%)	3.39	34.12
Total sugars (%)	8.40	40.59
Vit. C (mg/100 g)	56.00	18.75

(Cherian, 1998)

Comparison of composition of fresh and dried pineapple

Nutrient content	Fresh pineapple	Solar dried
pH	3.60	3.78
Acidity (%)	1.18	1.16
Reducing sugars (%)	1.80	2.59
Vit. C (mg/100 g)	32.00	0.40

(Hari, 1995)

Irradiation

Ratnatunga *et al.* (1978) showed that as the ascorbic acid concentration increased, retention of the vitamin after irradiation also increased. Concentrated orange juice containing 196 mg/100 g ascorbic acid, on irradiation caused 8 percent loss. If the ascorbic acid concentration was 29.5 mg/100 g, loss was 60 per cent. The loss of ascorbic acid not only depends on initial concentration, but also on radiation dose. During irradiation ascorbic acid is converted to dehydro ascorbic acid and then to diketogulonic acid. Carotene in plant tissues appears to be more resistant to destruction by radiation due to protection against radiation induced free radicals. Thiamine in fruits is not affected by radiation where as niacine is radiation sensitive and this sensitivity is increased by presence of ascorbic acid (Ratnatunga *et al.*, 1978).

IV. Nutrient loss in chemical methods

Preservation by pickling

The preservation of fruits in common salt or in vinegar is called pickling. Spices and edible oil may be added to the product. Raw mango, lime etc. are preserved in the form of pickles. Pickling is done (1) by fermentation with dry salting or fermentation in brine. In dry salting, for every 100 kg fruits, 3 kg salt is used in alternate layers in the barrel. After 3/4th filling, the mass is covered with wooden board under some weight. Brine is formed in about 24 h. Fermentation is usually completed in 8 to 10 days at 27-30°C, but it may take 2-4 weeks in cold weather (Girdharilal *et al.*, 1986).

The addition of salt permits the naturally present lactic acid bacteria to grow, thereby rapidly producing sufficient acid to supplement the action of salt (Desrosier, 1970). Pickles are good appetizers. They add to the palatability of a meal and aid in digestion by stimulating the flow of gastric juice (Girdharilal *et al.*, 1986). Certain chemical changes occur during the production of pickles. During fermentation the acidity increased and pH decreased in the product. Total solid sugar and moisture content decreased during pickling. The ascorbic acid content decreased after one day of pickling and completely disappeared after 12-18 weeks of storage.

Preservation by sugar

The fruits are preserved in the form of jams, jellies, preserves, marmalades and candies by relying

upon the high solids - high acid principle (Desrosier, 1970). Jams, Jellies, preserves, marmalades and fruit butter are products from fruits with added sugar, after concentrating by evaporation to a point, where microbial spoilage cannot occur. Jellies and jams are semisolid masses made from not less than 45 parts by weight of fruit juice/pulp ingredient to 55 parts by weight of sugar. The substrate is concentrated to not less than 65 or 68% soluble solids in jellies and jams respectively (Desrosier, 1970; Girdharilal *et al.*, 1986).

Marmalade, a jelly like product, is made from citrus juice and peel along with sugar. It is concentrated to achieve the gel structure. Fruit preserves and candy are prepared similarly. The whole or pricked pieces are blanched, and slowly impregnated with syrups of progressively increasing sugar concentrations, until the sugar concentration in the tissue is high enough to prevent the growth of spoilage microorganisms. Fruit is removed from syrup, washed, dried, packaged and marketed as candied fruit (Girdharilal *et al.*, 1986).

Sreeja (1996) studied the qualitative changes in cashew apple products in storage with special reference to vitamin C.

Chemical composition of fresh cashew apple and processed products - A comparison

Parameters	Fresh pulp	Jam	Candy
T.S.S. (°B)	11.20	68.01	68.05
Reducing sugars (%)	15.20	15.21	15.28
Vitamin C (mg/100 g)	263	49.86	16.66

(Sreeja, 1996)

Chandran (1999) studied the quality characters of papaya varieties and product development. In this study papaya jelly was prepared and the chemical composition of jelly was compared with the fresh papaya.

Chemical composition of fresh papaya and Papaya jelly - A comparison

Parameters	Fresh papaya	Jelly
T.S.S. (%)	13.03	65.36
R. sugars (%)	9.85	32.71
T. sugars (%)	10.77	43.71
Vitamin C (mg/100 g)	69.06	23.86

(Chandran, 1999)

Cherian (1998) studied the development of papaya based products. In this study papaya butter was prepared and its chemical composition was compared with the fresh fruits.

Chemical composition of papaya fruit and papaya butter - A comparison

Parameters	Fruit	Butter
pH	5.85	4.36
T.S.S. (%)	10.5	49.73
Acidity	0.063	0.10
R. sugars (%)	3.39	17.65
T. sugars (%)	8.4	24.6
Vitamin C (mg/100 g)	5.6	23.52

(Cherian, 1998)

Preservation by chemical additives

Chemical preservatives are non-nutritive substances intentionally added in small quantities to food, to improve its appearance, flavour, texture or storage properties. The chemical preservatives are advantageous in maintaining the nutritional quality, enhancing the keeping quality, making fruits attractive and helping in their processing. Certain fruit products

namely squashes, cordials, syrups need chemical preservatives, for a fairly long period after opening the seal of the bottle pasteurization may cause cooked flavour in these products. The preservation power of chemical preservatives is governed by acidity of the product, these are only recommended for preserving acid products, whose pH is 4.5 or below (Desrosier, 1970). Two chemical preservatives, permitted for use in fruit and vegetable products by fruit products order (1955) are briefly described below.

Sulphur dioxide

It is available in gas, liquid and solid state. Generally, potassium metabisulphite, a dry chemical, is used. It is however, decomposed by weak acids like citric, tartaric, malic and carbolic acids, to form potassium salt and sulphur dioxide, which is liberated from potassium sulphurous acid with water, when added to the fruit juice or squash. As all the vitamins except carotenes are stable in acid medium, there is practically no loss of these vitamins during preservation with SO_2. SO_2 is more effective against bacteria and mould and less effective against yeast. SO_2 has an antioxidant property. It helps in retention of ascorbic acid SO_2 also prevents enzymatic and non-enzymatic browning. It cannot be used in the case of some of the naturally coloured juices on account of its bleaching action on anthocyanin. It cannot be used in products, which are to be packed in tin containers, because it not only acts on tin container causing pin holes, but also forms hydrogen sulphide, which has an unpleasant smell and also forms a black

compound with the iron of the base plate of the tin container (Girdharilal *et al.*, 1986). In the presence of manganese, oxygen and glycine at the pH of food systems, SO_2 catalyses to cause a very rapid destruction of β-carotene.

Sodium benzoate

It is a salt of benzoic acid, which is practically tasteless and odourless. Benzoic acid, the effective agent, is sparingly soluble in water (Girdharilal *et al.*, 1986). Sodium benzoate is 170 times more soluble than benzoic acid. An amount of 0.1% sodium benzoate is usually sufficient to preserve a product, which has been properly prepared and adjusted to pH 4.5 or below. It is commonly used in preserving apple cider, syrup, pickles, other acid foods and especially in the products which contain water soluble plant pigments such as anthocyanin (Desrosier, 1970; Girdharilal *et al.*, 1986).

Preservation by fermentation

Fermentation is a process of anaerobic oxidation of carbohydrates. Wine is the product of an alcoholic fermentation of juice of ripe grapes. During alcoholic fermentation 2 gms of sugar will yield 1 g of alcohol. So there will be an increase in alcohol content and decrease in the reducing sugar content. The vitamin C will not get lost in the course of fermentation (Bopaiah, 1982). During fermentation of one mole of glucose about 234 joules (56 K cal) of energy is released (Desrosier, 1970).

V. Nutrient loss during storage of fruit products

Canning

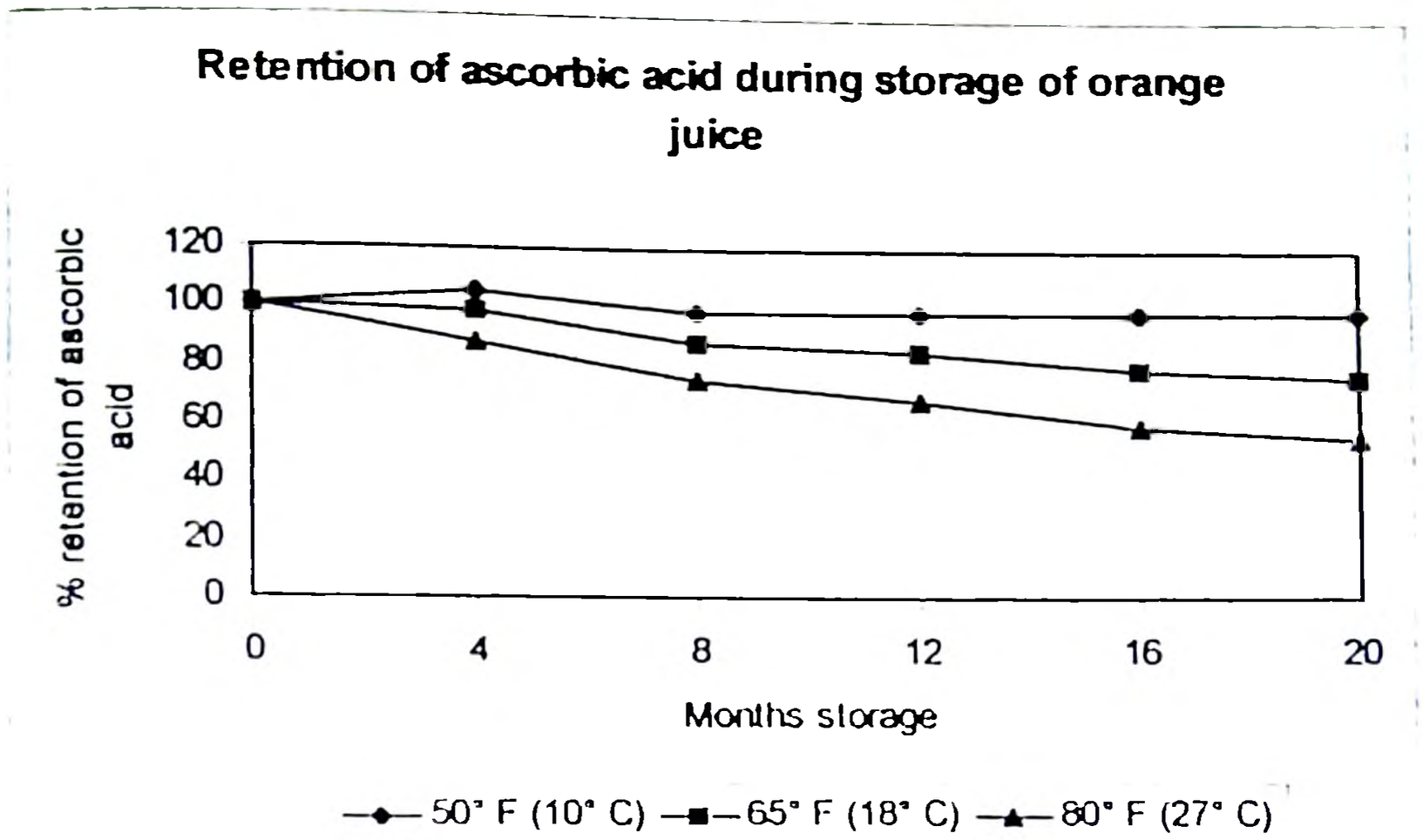
Effect of storage

The extent of nutrient loss during storage depends on 3 factors - the container used, the type of fruit and the storage temperature.

In bottles, due to oxidation of ascorbic acid by residual oxygen at the head space, there is a marked drop of Vitamin C initially. In cans, the tin protects the vitamin C in solutions. Ascorbic acid retention was higher in plain cans compared to glass containers, specially for low pH foods. Thiamine and Riboflavin losses are more in glass packed samples than in tinned samples.

There was 83 per cent vitamin C loss in pineapple and pineapple juice in 4 months storage while guavas had only 52 per cent loss for the same period.

Canned fruits retain their good flavour and nutrient properties for an extended time if they are held at moderately low temperatures. The effect of high temperature storage varies with the product and seems to be related to its pH. The ascorbic acid in canned orange juice is lost faster during high temperature storage. Carotene is also affected. The storage temperature has less effect on riboflavin than thiamine and ascorbic acid. Niacin is very stable to heat, light, oxygen and acid and is generally not lost in canning.



A comparative study was done by Doreyappa Gowda and Ramanjaneya (1995) on changes in the chemical composition of canned mango juice on storage.

Parameters	Canned juice	Canned juice (12 months storage)
T.S.S. (°B)	20.8	21.2
pH	3.6	3.7
Acidity %	0.5	0.3
Reducing sugars %	6.9	13.4
Carotenoids (mg/100 g)	5.1	2.7
Vitamin C (mg/100 g)	13.1	11.7

(Doreyappa Gowda and Ramanjaneya, 1995)

Pasteurization

Effect of storage

Ghosh *et al.* (1982) made a study on the preservation of pasteurised fruit juices and pulp in flexible pouch. It is observed that pasteurised mango pulp in polypropylene pack has a shelf life of 3 months at 5°C and 2 months at 37°C.

Storage of mango pulp (pasteurized) in 300 gauge polypropylene

Conditions of storage	Chemical changes on storage			
	Carotene content	Vitamin C	Total sugar	Reducing sugar
Soon after pasteurization	16% loss	47% loss	Increases from 10.8 to 11.8	Increases from 4.1 to 6.9
Storage at 5°C upto 3 months	27% of the residual content lost	79% of the residual content lost	Remains constant	Remains constant
Storage at 37°C upto 2 months	Practically nil	About 97% of the residual content lost	Remains constant	Increases further to 9

Freezing

Effect of storage

Alternate freezing and thawing during storage is particularly destructive to vitamins. Vitamin C losses continue on storage in frozen stage. Losses of vitamin C in frozen foods are higher than other vitamins. Further, little losses in thiamine in storage at less than 0°C also occur. Riboflavin levels are lowered during preparation for freezing but little or no losses occur during frozen storage. Carotenes are altered very little by freezing, though blanching improves their storage stability (Ralnatunga *et al.*, 1978).

Dehydration

Effect of storage

Dabhade *et al.* (1980) studied the changes in chemical constituents of mango powder during storage. Mango powder prepared from blanched, sundried and cabinet dried were packed in a packaging materials - Polyethylene bags and paper bags. The observations are shown in the following table.

Changes in chemical composition of Blanched mango powder (Sundried and Cabinet dried) on storage (6 months)

Parameters	Sun dried		Cabinet dried	
	Polyethylene bag	Paper bag	Polyethylene bag	Paper bag
Acidity %	5.6 - 4.8	5.6 - 4.6	3.58 - 1.45	3.58 - 1.35
Reducing sugars %	13.06 - 17.00	13.06 - 17.30	12.20 - 16.10	12.20 - 16.15
Total sugars %	17.36 - 21.00	17.36 - 21.34	16.30 - 20.05	16.30 - 20.16
Ascorbic acid (mg/100 g)	53.20 - 22.46	53.20 - 22.19	30.88 - 14.24	30.88 - 14.20

Rao *et al.* (1980) reported storage studies of the mango sheet. The storage studies was for three months at varying temperatures 20, 30, 40°C. During the storage of mango sheet, acidity and reducing sugar increased with the increase in storage temperature. Initially, the acidity was found to increase with the increase in sulphur dioxide content, this may possibly be due to formation of sulphurous acid. Increase in reducing sugar may be due to the increased rate of inversion during increased storage temperature. With the increasing storage temperature there was a corresponding decrease in ascorbic acid and carotene content. It was also observed that higher the level of SO$_2$, higher was the retention of ascorbic acid and carotene content.

Preservation by sugar

Effect of storage

Sreeja (1996) studied the changes in the chemical constituents in cashew apple products during storage.

Chemical constituents	Fresh jam without storage	Jams stored for 6 months
T.S.S.	68.01	70.05
Reducing sugar	15.21	15.76
Vitamin C	49.86	43.40

Cherian (1998) studied the effect of storage on the chemical composition of papaya butter.

Acidity increases during storage. This may be due to the interaction of organic acid present in the fruit. Due to increase in acidity, the pH decreases. The total soluble solids increases during storage. This may be due to partial loss of moisture and partly to the conversion of insoluble constituents into soluble forms. The reducing sugar increases during storage due to hydrolysis of sugars by acid which might have resulted in degradation of disaccharides to mono saccharides. Vitamin C decreases during storage. This reduction may be explained by the sensitivity to light and atmospheric temperature.

Preservation by chemical additives

Effect of storage

Ghosh *et al.* (1982) made a study on the preservation of fruit pulp in flexible pouch. It is observed that the mango syrup preserved with SO_2 retain a better quality and has a shelf life of at least 5 months under ambient temperatures.

The observations are given in the following table.

Storage of mango syrup (pre served by SO_2) under ambient condition in 300 guage poly propylene pouch

	Chemical changes on storage upto 5 months				
	SO_2 content ppm	Carotene content (mg/100 g)	Vitamin C (mg/100 g)	Total sugar (%)	Reducing sugar (%)
Mango syrup	**Reduced from 350 to 95**	**20% loss**	**9% loss**	**Changes from 48 to 20**	**Changes from 15 to 25**

Chemical composition of mango pulp stored in HDPE containers and glass bottles (preserved with SO_2)

Treatment	Period of storage	Package used	Total carotenoids (mg/100 g)	Reducing sugar %	Total reducing sugar %	Free SO_2 (ppm)
Mango pulp + 250 ppm SO_2	6 months	HDPE	15,790	3.44	11.00	60
		Glass	16,200	3.56	10.07	60
	12 months	HDPE	15,505	6.80	7.80	Traces
		Glass	15,840	5.30	9.00	Traces

(Murthy *et al.*, 1982)

VI. Studies conducted at KAU

Fruit	Treatment	Nutrient change	Author
1. Fresh mango	Before canning	Ascorbic acid – 8 mg/100 g	Kuriakose, 1982
Mango slices in syrup	Canned	2.6 mg/100 g	
2. Fresh mango	-	28.13	Jyothi, 1997
Mango pulp	Heat treatment	12.45	
3. Fresh Banana	-	7 mg	George, 1994
Dried Banana product	Osmotic dehydration	0.2 mg	
4. Fresh pineapple	-	32 mg	Hari, 1995
Dried pineapple product	Dehydration	0.4 mg	
5. Fresh papaya	-	56 mg	Cherian, 1998
Papaya leather	Sun dried	18.75 mg	
Papaya butter	Preserved using sugar	23.52 mg	
6. Fresh papaya	-	69.06	Chandran, 1999
Papaya jelly	Preserved using sugar	23.86	
7. Cashew apple pulp (fresh)	-	263	Sreeja, 1996
Cashew jam	Preserved using sugar	49.86	
Cashew candy		16.66	
8. Fresh jack fruit	-	7.00	Oommen, 1995
Dried jack fruit product	Osmotic dehydration	0.18 mg	

Conclusion

Thus we have seen the various methods of fruit preservation. These preservation methods add value to the finished product which is whole some, nutritious and available round the year. Each method has its own advantages and disadvantages and a judicious combination of these methods should be adopted for economic and successful fruit preservation.

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DISCUSSION

Q. Which is the most abundant mineral found in fruits?

A. Potassium

Q. Is there any classification of chemical preservatives?

A. Yes. F.P.O. classifies the chemical preservatives into two - Class I and Class II preservatives. Class I includes the natural preservatives and Class II includes the chemical preservatives.

Q. Which is the best method by which there is maximum retention of nutrients?

A. Cryogenic freezing

Q. Why vitamin C is retained more in cans than in glass bottles?

A. Vitamin C is a nutrient that will be destroyed by oxidation. In cans, the oxygen in the can headspace will be removed by the exhausting process. So the vitamin C will not get oxidized and it will be retained in cans. But in glass bottles, the oxygen present in it will oxidize the vitamin C and so there will be considerable loss of this vitamin.

Q. Of the 2 types of drying, sun drying and mechanical drying, which drying method has more retention of nutrients?

A. Mechanical drying has more retention of nutrients than sun drying. Sun drying being a rapid drying process nutrient loss will be more in that compared to mechanical drying.

Q. Which pasteurization method is best for wine making?

A. HTST.

ABSTRACT

India ranks number one in world fruit production with a share of 42.17 million tonnes (Chadha, 1999). Fruits in human nutrition make the diet balanced which leads to the development of sound health and happiness of human beings. Fruits are rich sources of valuable vitamins, minerals and other nutrients and therefore are considered as 'protective food' (Singh, 1995).

Fruits are highly perishable and hence to reduce wastage and to make it available throughout the year, the fruits should be processed into value added products (Khurdiya and Roy, 1985). The fruit processing industry has been declared as a thrust area and is now a potential earner of foreign exchange through export of processed fruit products (Kapoor, 1993).

There are various methods of fruit processing and preservation. These include physical methods and chemical methods. These methods can change fruits and vegetables into new or more usable forms and make them more convenient to prepare. But considerable nutrient loss occurs during preservation and storage of fruits which has to be given special attention (Khurdiya, 1995).

Each method of fruit processing and preservation has its own advantages and disadvantages. So a judicious combination of these methods should be adopted for minimising the nutrient loss and also for economic and successful fruit preservation (Khurdiya, 1995).

BIOAVAILABILITY OF MICRONUTRIENTS FROM LEAFY VEGETABLES

By

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(2000-16-01)

M.Sc. (Home Science)

SEMINAR REPORT

Submitted in partial fulfillment for the requirement of the course No. Home Science 651, Seminar

DEPARTMENT OF HOME SCIENCE
COLLEGE OF HORTICULTURE
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA - 680 656

DECLARATION

I, Vineetha Kumaran (2000-16-01) hereby declare that seminar entitled "BIOAVAILABILITY OF MICRONUTRIENTS FROM LEAFY VEGETABLES" have been prepared by me, after going through the various references cited here and has not been copied from my fellow students.

Vellanikkara
Date : 3-11-2001

Vineetha Kumaran
(2000-16-01)

CONTENTS

BIOAVAILABILITY OF MICRONUTRIENTS FROM LEAFY VEGETABLES

1. Introduction

Leafy vegetables form the most nutritive menu of man and tone up his energy and vigor. They are within the reach of poor man and occupy an important place among the food groups as they provide adequate amounts of many vitamins and minerals for human nutrition. They are rich sources of β-carotene (a precursor of Vitamin A), vitamin C, riboflavin, folic acid and minerals like Calcium (Ca), Iron (Fe). They are fair source of protein. When compared on a dry basis they are equal to legumes in protein content (29.8 g/100 g).

According to Gopalan *et al.* (1999) the nutritive values of some commonly consumed leafy vegetables of Kerala (per 100 g of edible portion) are:

Name	Protein (g)	Carotene (µg)	Vitamin C (mg)	Fibre (g)	Minerals (mg)	Ca (mg)	Fe (mg)
Amaranth	4	5,520	99	1	2.7	397	8.49
Chekkumanis	6.80	5,706	247	1.4	3.4	570	28
Colacasis (black)	6.80	12,000	63	1.8	2.5	460	0.98
Cowpea leaves	3.40	6,072	4	1.2	1.6	290	20.1
Drumstick leaves	6.7	6,780	220	0.9	2.3	440	0.85
Pumpkin leaves	4.60	-	-	2.1	2.7	392	-

- Values not reported (Gopalan *et al.*, 1999)

These nutritive values are determined by chemical analysis and may be quite misleading in terms of nutrient status of a food. Apart from amount, what is more important is to see whether these nutrients are present in a form that can be utilized through metabolism, i.e. whether the nutrients are bioavailable? Bioavailability

effects the nutritive value of foods. A laboratory analysis tells us that a food contains specific nutrient but it does not mean that those nutrients are present in a form that is available to our body. Here comes the importance of bioavailability of micronutrients.

Bioavailability

Bioavailability is defined as the degree to which food nutrients are available for absorption and utilization in the body (Epsy, 1977). Thus bioavailability of nutrients are related to the efficiency with which the nutrients present in foods are utilized for performing biological functions. These include:

1. Release of nutrients into the gut lumen from the food matrix following digestion.
2. Uptake by mucosal cells and their transport into the body.
3. Wherever applicable conversion of precurson to active ingredients in the mucosal cell (Vijayaraghavan, 1998).

Many vitamins are present naturally in foods in bound form. Similar is the case with minerals, which adversely affect our ability to use them. Gupta and Saxena (1977) reported that the incidence of nutritional deficiency diseases were high in vegetarians than non vegetarians. They have also reported the occurrence of vitamin A, anaemia, B complex deficiencies.

Why do we care about measuring bioavailability?

Role of bioavailability is important in establishing nutrient requirements and using those

requirements in food labelling. The amount of a nutrient in food that the body can actually use may vary depending on age and physiological conditions. Nutrient drug interactions may alter nutrient bioavailability and thus effect the nutrient status of individuals who are taking such drugs.

Nutrient availability is also important in testing and marketing infant foods, nutritional supplements and enteral formulas.

So knowledge of nutrient bioavailability is a key to understand the role of nutrients in maintaining human health. Improved knowledge of nutrient bioavailability helps in providing definitive quantitative dietary guidance, it can help us translate what we know into optimal and desirable eating pattern and food choice (Epsy, 1996).

Micromutrient deficiency affects approx. 2 billion people world wide (roughly $1/3^{rd}$ of human race). As a result of micromutrient deficiency, a large proportion of the worlds population is placed at risk of diseases, disabilities and even death. The major nutritional problem in India are vitamin A deficiency, iron deficiency and iodine deficiency.

Micromutrients are defined as dietary constituents which are essential for growth and development. They are also essential for maintenance of adequate defence against infections, diseases and for many other metabolic and physiological functions. Eventhough these are 24 minerals related to human body only 16 minerals are necessary. They help to achieve satisfactory rate of growth and development and helps to maintain optimal health. In human, minerals are present:-

- In combination with other inorganic ion
- In combination with other organic ion
- As free ions.

Vitamins can be mainly divided into two. fat soluble (Vit. A, Vit. D, Vit. E, Vit.K) and water soluble (B complex and Vit. C). The main functions are

1) body maintenance
2) body regulating
3) cofactor.

Micronutrients do not undergo an elaborate digestion process, most of them do not require any major structural alternation to get absorbed. However digestion is essential for liberation of vitamins and minerals from proteins, fats or carbohydrates, with which they are normally associated.

The absorption of micronutrients commences in stomach, where a small fraction of water soluble vitamins (except Vit.B12) and minerals are absorbed. Most absorption takes place in small intestine. There Vit. B12 is absorbed with the aid of intrinsic factors secreted by gastric parietal cells. Fat soluble vitamins are absorbed in association with bile salt micelles together with fatty acid monoglycerides. Absorption failure results from 4 main causes, namely deficiency in digestion and secretion, damage to brush border and mucosal cells and nonphysiological factors (eg. presence of nutrient antagonists in foods).

Factors affecting the bioavailability of micronutrients:-

1) Chemical form in which micronutrients are present
2) Nature of other dietary constituents

3) Stability to cooking and processing

4) Efficiency of an individual's digestive system

1) Chemical form in which micronutrients are present

Certain nutrients may be present in foods in chemical forms that are biologically unavailable, for eg: dietary Fe exist in 2 major forms, namely heme Fe and nonheme Fe. Heme Fe is found in animal foods and nonheme Fe found in plant foods. The 2 forms are absorbed by different mechanisms. Heme Fe is more effectively absorbed (upto 22% of dietary content) than nonheme Fe from plant sources (cereals 1-6%). Similarly Zinc (Zn) in foods of animal origin is better absorbed than that in plant foods.

2) Nature of other constituents of diets

The influence of other dietary constituents on the bioavailability of a given nutrients may be positive in the sense that assimilation of nutrients is enhanced or negative (in that availability is impaired). The absorption of many inorganic nutrients (Ca, Fe and Copper (Cu) are independent and in some cases (Ca) may also depend on specific vitamins. Active Vit.D enhances Ca absorption by stimulating the synthesis of Ca binding protein in gastro intestinal tissues.

Negative influence on bioavailability is exerted mainly by the non nutrient constituents like oxalic acid, phytic acid, proteinase inhibitors and avidin.

In raw foods, these substances are normally held in separate compartments away from nutrients but come into contact during processing or digestion in the gut. At intestinal pH (alkaline) oxalic acid, phytic acid and

avidin reacts with the respective nutrients to form insoluble complexes which are not readily absorbed there by rindering the nutrient unavailable. Oxalic acid forms oxalates, precipitates with dietary Ca, while phytic acid forms insoluble phytates with Ca, Fe, Zn and possibly other metals. Avidin reacts with vitamin biotin and makes it unavailable.

3) Stability of cooking and processing

The micronutrients are most adversely affected during food preparation. The extend of loss of a given nutrient varies with method of preparation. Losses from boiling can be minimised (especially the water soluble vitamins) if cooked water is retained.

4) Efficiency of gastrointestinal tract

Generally the efficiency of digestive system varies from individual to another, with higher efficiency in females than in males of same age and in adolescents than in elderly. Thus the availability of a given nutrient to any 2 individuals consuming exactly the same diet may not necessarily be the same. For eg., the availability of fat soluble vitamins depend on the bile salts secreting capacity of liver. Chronic infection by gut parasites leads to impaired bioavailability of fats, vitamins especially Vit.B_{12}, Vit.C, folic acid, Vit.A and mineral nutrients particularly Fe and Se.

The major micronutrients present in leafy vegetables and whose bioavailbility studies have been carried out are Vitamins - β-carotene (Pro Vitamin A), Minerals - Ca, Fe and Zn.

The most active part of the plant is the leaf, where in the photosynthetic process occurs. Many nutrients are concentrated in the leaves such as protein, Vitamin A, Vitamin C, Fe and Ca (Wenck *et al.*, 1980).

2. Bio availability of β-carotene : Pro Vit. A in the form of carotene and other carotenoids is commonly found in plant foods. Vit. A activity in plants resides in the carotenoid pigments, which are precussor to the vitamin in the animal body and therefore designated as pro. Vit. A. This is converted to retinol in the small intestine. In many developing countries including India the main source of dietary Vit. A is carotene. Unlike retinol, carotenes are not absorbed completely. Studies in adults with carotene rich foods present in their habitual diets of Indians have shown that on an average 50% of dietary carotenes are absorbed (Rao, 1998). β-carotene is the most predominant provit. A in all leafy vegetables constituting 30-50% of total carotene, except in fenugreek leaves containing more than 80%. Highest concentration of β-carotene in drumstick, agathi leaves - 15-20 mg/100 g. Amaranth - 8-10 mg/100 g, Gogu - 5 mg/100 g.

Palak contains modest amounts of β-carotene but since they are consumed frequently and in greater amounts, so contribute significantly to vit. A content of diet.

Analysis of less familiar leafy vegetables (Tulasi, ponnaganti-8-10 mg of β-carotene) showed substantial amounts of β-carotene indicating that many of

the less familiar leafy vegetables are on par with cultivated species (NIN, 1994b).

Devadas and Saroja (1979) conducted studies on bioavailability of β-carotene and Fe from amaranth and found that their daily inclusion in diet is capable of combating Fe and Vit.A deficiencies.

Season also has an influence on β-carotene content and this seasonality varies significantly in leafy vegetables (Bhaskarachary, 2000; Mathew *et al.*, 2000). Eg. Agathi, hibiscus, drumstick, curry leaves - higher conc. during summer and mint and spinach during rainy season.

As far as bioavailability of micronutrients from plant foods are concerned several factors like rate of release from food, size of food particle, dietary fat, fibre, protein intake, food processing, presence of intestinal parasite can inhibit or facilitates their bio-utilization.

The absorption of β-carotene is the first permissible step in conversion of vit. A and conversion is intracellular. The major site of conversion of β-carotene to Vit.A is the intestinal mucosa with the help of enzyme dioxygenase. Other tissues such as liver, kidney can also convert β-carotene to Vit.A but this does not happen in man to any significant extend.

Regulation of conversion of β-carotene to Vit. A.

1) Dioxygenase activity - severe, but not mild protein deficiency lowers activity
2) Starvation has no effect

3) Vit. A deficiency increases activity
4) Dietary protein - Biological value influence conversion
5) Zn status - Deficiency interfers
6) Vit. A status - Deficiency interfers

Studies at NIN showed that absorption of β-carotene is higher than that of total carotene in both adults and children. The absorption of total carotene and β-carotene from pumpkin leaves in meal form was found to be 58% and 72.75% respectively, showing that the percentage of absorption of β-carotene was higher than total carotene (Chandrasekhar *et al.*, 2000). It is some what surprising data that β-carotene absorption in man is limited and the absorption varies from one food to another.

There are wide variations between individuals in absorption of β-carotene from the same dietary sources and it was observed that crystalline β-carotene is far more effectively absorbed than β-carotene from any food sources, including red palm oil (Rani, 1989).

Percentage of absorption of β-carotene in different human subjects from different food sources

Food sources	Subjects						
	1	2	3	4	5	6	7
Amaranth	70	75	-	61	45	-	-
Leaf concentrates	-	-	-	77	-	-	-
β-carotene	99	-	85	85	-	99	9-17
Papaya	90	-	-	-	-	-	-
Red palm oil	-	-	-	-	65	-	-

(Rani, 1989)

The table also indicates that pure β-carotene is absorbed almost completely, while the absorption from food sources varies from 40-90%.

Individual variability in absorption of β-carotene in man.

Food sources	% Range
Amaranth	11-78
Papaya	[illegible]-49.[illegible]
Leaf protein	[illegible]8-40

NIN showed that when preschoolers were given supplements [illegible] amaranth [illegible] spinach there was a significant [illegible] serum [illegible] level. Similar observations [illegible] by several other workers confirming [illegible] leafy vegetables in Vit. A [illegible]. There was no change in serum retinol level, [illegible] serum [illegible] less than [illegible] higher levels (NIN, [illegible]).

[illegible] absorption [illegible] influenced [illegible] revealed [illegible] β [illegible] undernourished children [illegible] normal adults. An intake of [illegible] vegetable [illegible] for [illegible] days [illegible] was found to be advantageous [illegible] and Nandhini, [illegible]).

When we consider the in vitro factors the leaf maturity is an important determinant of β-carotene bioavailability. Studies conducted at NIN (1994a) indicated that tender or medium textured leaves and those harvested either in morning or evening, rather than mid

day were found to be better source of β-carotene than coarse or even mature leaves. Seasons also have an effect on the β-carotene content of leafy vegetables (Mathew, 2000).

According to Devadas *et al.* (1980) absorption of β-carotene in amaranth is lower than that in papaya and carrots. This may be due to the difference in fibre content.

Rani (1989) studies the impact of dietary intervention of drumstick leaves and egg in children and found that drumstick leaves had a better impact on Vit. A and Hb level when compared to supplementation with egg. The reasons may be

1) Fe content of drumstick leaves enhance the bioavailability of Vit. A
2) Large amounts of Vit. C present in drumstick leaves enhances absorption of Fe and thereby increasing the Hb content.

It has been established that β-carotene and fat must be present simultaneously in the gut for effective absorption. According to Giri and Nandhini (1985) a dietary fat at 10% level is more promising for preschool children for a better utilisation of β-carotene from amaranth. Results also indicated that the absorption of β-carotene was more for groundnut oil than from sunflower oil at both 10 and 20 g levels.

Percentage absorption of total carotene in human studies

Food sources	Without fat	With 20 g fat
Amaranth	35.5	78
Spinach	52.3	88.8

(Giri and Nandhini, 1985)

In India, a substantial population of rural poor and urban slum dwellers use little or no fat in their habitual diet. Since it is in this very segment of population that Vit. A deficiency is seen, it becomes important to determine the extend to which dietary β-carotene is absorbed.

Sood and Bhat (1974) observed a loss of 5-83% of β-carotene during preparation.

When green leafy vegetables were fried in little oil, resulted in higher loss of Vit. A when compared to green leafy vegetables boiled in restricted quantity of water (Rao, 1967).

But studies by Rani *et al.* (1995) showed higher retention of β-carotene when cooked in small amounts of oil (retention ranged between 41-100%).

Chandrasekhar *et al.* (2000) found that poriyal form of pumpkin leaves helped to retain higher amounts of β-carotene in adults. This may be due to extraction of fat soluble carotenoids in the fat. Bhaskarachary *et al.* (1995) found sautéing as the best method followed by steaming, cooking with lid and least retention when cooked without lid.

Mean retention of total carotene and β-carotene following simple processing of vegetables

Vegetable	Carotene	Raw	Cooking without	With lid	Steam	Sauteing
Green leafy vegetable	Total carotene	11.6	63	67	9	73
	β-carotene	5.6	38	47	53	67

(Bhaskarachary *et al.*, 1995)

Lakshmi and Vimala (2000) reported that inspite of considerable loss in Vit. C, green leafy vegetable

powders retained good amounts of β-carotene. Thus drying these leaves does not alter absorption.

Peddi *et al.* (1994) showed that cooking at elevated temperature in the presence of O_2 is said to cause conversion of all trans carotene to cis-carotene, which decreases the Vit. A activity. β-carotene content remained stable upto 15 days in gogu pickles (96% retention). But nearly 80% of carotene was lost after 60 days of preservation (Bhaskarachary *et al.*, 1995).

Sauteing by addition of tamarind or tomato in preparation of dhals with amaranth has better retention of total (92%) and β-carotene (72%) compared to ordinary cooking. The studies conducted by Rani *et al.* (1995) revealed that the presence of weak organic acids help in higher retention of β-carotene in the case of chutnies containing green chillies, tamarind etc.

Thus, undeniably the bioavailability of carotenes from plant foods is lower than the performed Vit. A. But this does not imply that carotene rich foods are not effective in combating Vit. A deficiency. If they are consumed in adequate amounts they can meet the daily requirements of Vit. A. They also provide Fe, folic acid, Vit. C and other micronutrients.

3. Bioavailability of Fe : Types of dietary Fe: There are two distinct types of dietary Fe, heme and non heme Fe. Heme iron is a constituent of hemoglobin and myoglobin and is therefore present in meat, fish, poultry. The second type of dietary Fe is the non heme Fe. It is found to varying degree in all food of plant origin. Accumulating evidences demonstrate that the amount of Fe

potentially available from food depends not only from the amount of Fe intake but from the nature of Fe present and composition of the meal in which it is consumed. Thus, the total Fe content of a diet is poor indicator of amount of Fe that is really absorbed and utilized (Hallberg and Rossander, 1991). The absorption of non heme Fe in diet can vary upto 10 fold depending upon the dietary content of inhibitors. Eg. dietary fibre can alter dietary Fe bioavailability (Devi, 2001).

It has been seen that in general Fe from animal food, especially meat, is absorbed 3-4 times more than Fe from vegetable sources. Exception are egg, milk and its derivative in which the percentage of Fe absorption is similar to that found in vegetable foods (Santos *et al.*, 1980).

Fe absorption is defined as the percentage of ingested Fe that after digestion of food, has passed the mucosal cell and is taken up by the blood. Bioavailability is the percentage of ingested Fe that becomes available for metabolic action. Poor Fe bioavailability has been reported extensively as a prime factor in considering the aetiology of Fe deficiency anemia in developing countries (Hallberg *et al.*, 1983). A majority of Indian population are vegetarian. Vegetarian food stuffs are known to have nonheme Fe which has low bioavailability.

In healthy individual, 4 main factors determine Fe absorption:

(1) Physiological need for Fe (2) Dietary Fe intake (3) Bioavailability of dietary Fe (4) adaptation. Adaptation is the ability of mucosal cells to adjust Fe absorption

to physiological demands and to the bioavailability of dietary Fe (Cook, 1990).

Absorption of Fe occurs in small intestine and it is most efficient in upper portion (Conrad, 1970, Rao, 1977). Its absorption is affected by several factors. One of there is the body's need for Fe. Eg. Pregnanacy increases the need for Fe. A large percentage of available Fe is absorbed when a woman is pregnant than when she is not (Hallberg, 1987).

In Fe deficiency state the non heme absorption can increase about 10 fold and heme Fe can increase upto to 2 fold.

Another thing which affects absorption is the state in which Fe occurs. Readily soluble forms and Fe compounds in a ferrous state are more efficiently utilized than other forms. Ferric ion (Fe^{3+}) is poorly absorbed, much of Fe in food is in ferric form. Fe absorption will be improved if Fe^{3+} is reduced to Fe^{2+} within the intestinal tract. This reaction is favoured by an acidic medium (Raj, 1997). Reducing agents like Vit. C and presence of acidic medium favours absorption. Rathee and Pradhan (1980) reported an increase in absorption of Fe when Vit. C was supplemented with egg. This may be because Vit. C serves as a vehicle not only to counter act the inhibiting effect of egg in diet, but also increase the Fe absorption from normal diet. The reason may be its role in the reduction of Fe to more soluble ferrous state, it forms an Fe ascorbate chelate thus improving Fe absorption in body.

According to Haque and Chakrabarti (1982) the absorption of Fe can be improved by administration of

protein. Kroe *et al.* (1966) suggested that the formation of Fe amino acid chelates increases Fe absorption.

The total Fe in green leafy vegetable ranged from 1.9 - 1.8 mg/100 g fresh edible portion. The Vit. C content of green leafy vegetable ranged from 21-135 mg/100 g edible portion. According to Reddy *et al.* (1998) the availability of Fe depends upon the maturity of leaves. They found that there was a rise of total Fe content and a decrease in the percentage of total available Fe in leafy vegetables with advancement of growth.

Certain substances combines with Fe in intestine to form insoluble compounds which cannot be absorbed. Important among these are phytates, phosphates, oxalates and fibre. Fe from vegetable origin was much more surrounded by these inhibitors than Fe from animal origin (Dokkum, 1992). The excess of phytate in the diet reduced the percentage of Fe absorbed from intestine. The polyphenols and phytates in plant foods are known to bind with non heme Fe and thus inhibit its absorption (Craig, 1994). Though dietary fibre has many advantages like it is effective in reducing incidence of obesity, hypercholestremia, diverticular disease, colon diseases and constipation they bind with divalent metal ions and thus make it unavailable. Kowsalaya and Mohandas (1999) estimated the anti-nutritional factors present in raw leaves of cauliflower and reported that Tannins - 1.6 mg/100 g, oxalates - 26 mg/100 g, phytates - 45 mg/100 g. Oxalates decreases Fe absorption. Leafy Vegetable and other vegetable contains oxalic acid which inhibits Fe absorption.

Nirmala *et al.* (1985) reported total Fe content in amaranth to be every high when compared with cereals and pulses but absolute available Fe content was very less compared to total Fe content. This may be due to the presence of phytate, phosphate, oxalates.

Foods	Total Fe from food (mg/100 g)	Absolute available Fe (mg/100 g)
Cereals		
Parboiled rice	2.8	0.23
Pulses		
Red gram	3.8	0.76
G.L.V.		
Amaranth	7.5	0.4
Ponnanganni	7.97	0.28

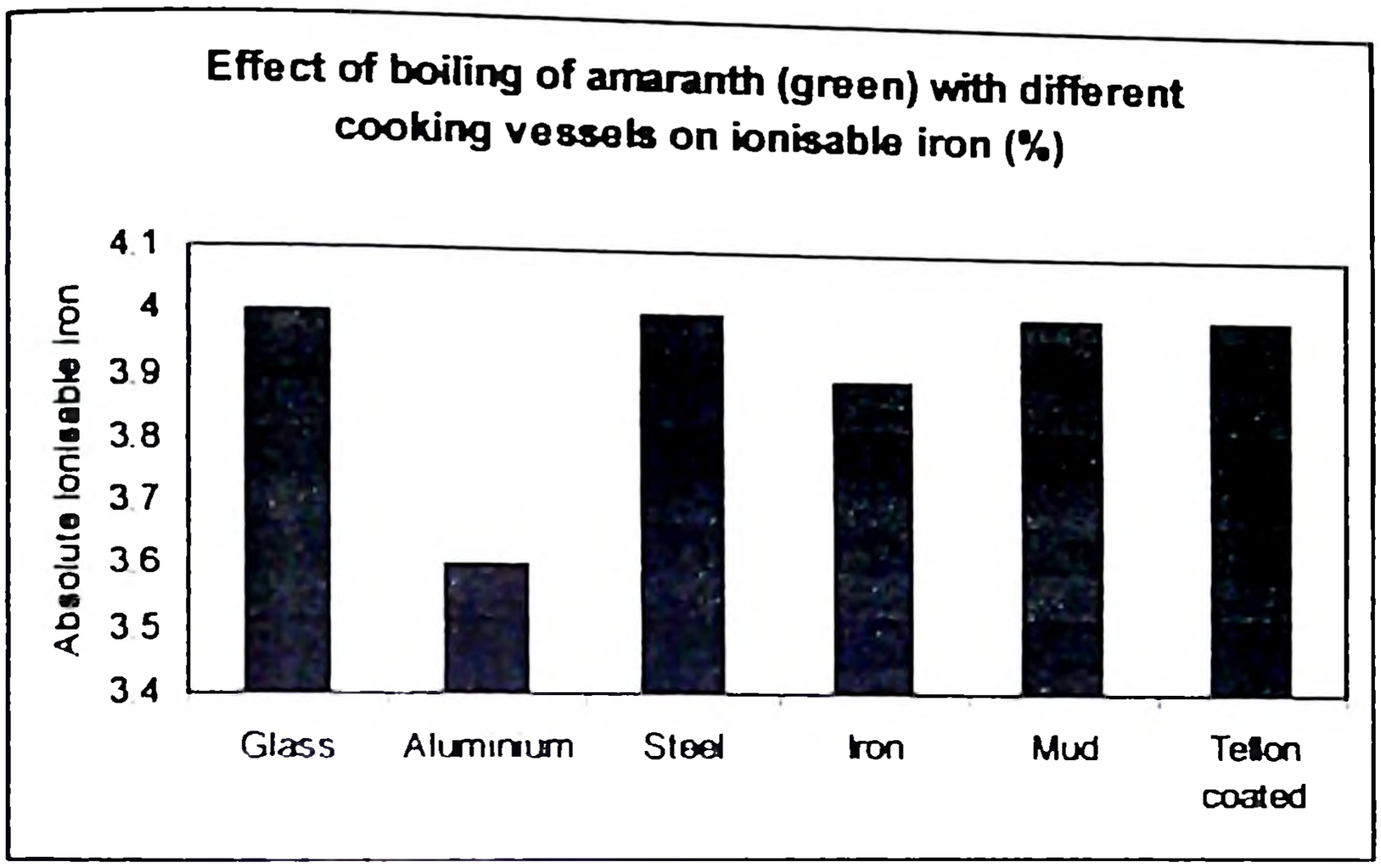
(Annapurani and Murthy, 1985)

The significant increase in absolute available Fe is due to decrease in poly phenols after cooking to about 20-50% (Kakade and Agte, 1997).

Studies conducted by Hallberg *et al.* (1983) and Arora (2000) on effect of cooking of leafy vegetables in Fe utensils showed an increase in total and ionisable Fe, highest in amaranth and then spinach, fenugreek. The results suggested that different vegetables differ in their capacity to dissolve Fe from Fe pans. The increase in Fe content of foods by cooking in Fe utensils to a variable extend depends on the type of preparation of foods. It was noticed that there was a significant increase in total and ionisable Fe in each vegetables due to use of tomatoes as an ingredients which solubilized Fe from pan as well as increased the ionisable Fe due to the different acid and Vit. C content present in it.

Frying showed not much difference in total iron content but ionisable iron at pH 7.5, showed increase which ranged between 2-5% when cooked in glass vessel (Usha, 1994).

(Usha, 1994)



Boiling and frying of green leafy vegetables in different cookware indicated that glass, mud, steel and teflon coated vessels were inert for cooking whereas in aluminium vessels, the lowest ionisable iron was observed. Iron vessels increased total iron content but there was no significant increase in the ionisable Fe content indicating that cooking of foods in iron vessels has no beneficial effect in the body.

Excess of unavailable iron in the body causes heamosiderosis and hence damages the liver (Begum, 1996).

4. Bioavailability of Calcium : Ca exist in foods mainly as complexes with other factors (phytates, oxalates, lactate and fatty acids) from which must be released to

be absorbed. The factors affecting Ca absorption from gut.

Favours	Decreases
Acid pH	Phytates
Soluble form	Fibres
Bile salt	Oxalates
Lactose	Alcohol
Vit. D excess	Fats
Pregnancy	Low protein diet
Ca deficiency	Age
Lactation	Menopause

(Reddy, 2001)

Leafy vegetables excluding members of goosefoot family, such as spinach and chard that contain oxalic acid, rank next to the dairy products in Ca content. These calcium are present as insoluble oxalates and cannot be absorbed (Wilson *et al.*, 1971).

Plant constituents of diet, in particular, may reduce Ca bioavailability so that people who do not use dairy products are less likely to obtain adequate amounts of Ca. Oxalates present in leafy vegetables normally binds with Ca in gut and the body excretes both together thus limiting Ca absorption and availability.

Vit. B_6 deficiency can reduce Ca availability. The forms present in plant sources may include a complex with a glucose molecule, which appears to reduce bioavailability of other forms of Vit. B_6.

Certain plants such as rhubarb (*Rheum rhapontium*) and spinach are known to contain rather high level of oxalic acid (Liener, 1980).

Experiments conducted on adult human by Pingle and Ramasasthri (1976) showed that Ca in amaranthus leaves are poorly absorbed, when given along with milk and indicated oxalate content as the reason for poor absorption of Ca. Marderosion *et al.* (1979) indicated that 40% oxalates in amaranthus is in free form and is available for binding with Ca from other sources contained in a diet.

The tender leaves of tamarind are eaten as vegetables. The leaves contain oxalic acid (196 mg/100 g) and showed a Ca/oxalate ratio 1:1 at pH 4.5, indicating that the leaves are good sources of Ca but oxalic acid affects their bioavailability (Shankaracharya, 1998).

According to Wenck *et al.* (1980), the amount of interference on absorption of Ca depends on quality of oxalic acid present.

Food	Ca (%)	Oxalates (%)	Ca:Oxalate
Spinach	0.12	0.89	1:7
Broccoli leaves	0.12	0.005	42:1
Mustard green	0.24	0.008	30:1

(Wenck *et al.*, 1980)

Eventhough the calcium in the foods cannot be used, it does not mean that they should be abandoned. Leafy vegetables are high in carotene and iron content.

In a study of children (5-8 years of age) with an adequate intake of calcium, no lessening of absorption of calcium was observed by the addition of a daily serving of spinach. So it would appear that with an adequate intake of calcium, the free oxalic acid makes no discernible difference in the absorption of Ca (Wilson et *al.*, 1971).

5. Bioavailability of Zinc : In general protein foods are best dietary sources of Zn and since protein consumption leads to decline with advancing age, protein especially animal protein also has a favourable effect on Zn availability. The vegetarians may have higher requirements because of lower availability of Zn from plant foods (Devi, 2001).

Factors affecting Zn absorption

Zn is absorbed in the intestinal tract in body. There are many dietary factors which influence its absorption. Protein deficient diets especially deficiency of Sulphur containing amino acids decreased Zn absorption. Similarly, foods rich in fibre, phytates, Fe, Ca, P and Cu also decreases Zn absorption on the other hand, there are dietary factors which enhances Zn absorption. The presence of folic acid, Vit. A and Vit. C help in enhancing Zn absorption. Studies conducted at NIN have shown that upto 16% of total dietary Zn is absorbed by the body. Absorption depends on type of diet consumed. In mixed diet the absorption is more than plant based diet (Devi, 1998). Absorption vary from 10-80% depending upon factors mentioned earlier. However an average absorption of 20% or more may be anticipated from diet unless the content of fibre and phytate is exceptionally high.

Gastro intestinal absorption in infants Vs adults

Great difference exist between infants and adults in respect of absorption of organic and inorganic constituents from the gastro intestinal track. Younger species absorb more effectively than older animals. The reason is not entirely clear. However the state of

development of gut during infancy is linked to the absence of development of selective absorption process on one hand and presence of passive transfer of molecule across the developing gut wall, on the other hand are believed to be crucial (Venkatesh, 1994).

Gut absorption of trace element in infants and adult human subjects.

Elements	Infants (%)	Adults (%)
Fe	16-50	10
Zn	50	20-40

(Venkatesh, 1994)

6. Leaf concentrates

Leaf concentrates are unconventional food resources of many nutrients like protein, Fe, folic acid, Ca and β-carotene. They are dark, almost black and may be used as such or dried into a powder. It is prepared from a variety of leafy vegetables (NIN, 1993).

Mathur *et al* (1989), Mundra and Mathur (2000) found that leaf conc. are effective in raising hemoglobin value of experimental group clearly showing that Fe in leaf conc. was effectively absorbed and was biologically available.

Govindas and Shanmugasundaram (1987) found that the β-carotene content, Ca, Fe content increased significantly in leaf concentrates.

Preschool children cannot consume large quanitites of leafy vegetables required to meet the RDI of Vit. A. A child has to consume 100 g spinach to meet RDI requirements. Results showed amaranth, spinach curd has 10-30% more β-carotene than fresh leaves. The advantages are:

1) Since it is already heated, no further processing is required

2) It is devoid of soluble oxalates

3) Bioavailability of β-carotene and other micronutrient increases by consumption of leaf conc. than leaf. Acceptability studies showed that they are acceptable among preschool children.

7. Conclusion

The leafy vegetables are rich source of β-carotene, Fe, Ca, Mg, Vit. C and other micro-nutrients but not much is known about its bioavailability. Eventhough compared to animal foods, bioavailability of micronutrients is less, we can improve their bioavailability through better cooking practices. Principles of consuming balanced diet with diversification in food items are necessary to maintain adequate macro and micronutrient status. New cooking procedure or processing methods that do not result in significant loss of Vit. A activity has to be adopted. In order to get the maximum nutrients they can be combined with other food groups and prepared. An alternate method is incorporation of leaf protein conc. in diets. Improved varieties of leafy vegetables which have improved quantities of β-carotene can be used in place of conventional leafy vegetables (Bhaskaracharya, 2000).

However many factors influencing nutrient bioavailability from leafy vegetables and the difficulties inherent in meaningful evaluation procedure leaves much research in these area still to be done.

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9. Discussion

1) Which are the improved varieties of leafy vegetables which can replace the conventional leafy vegetable?

Pusa Bharati, a new Indian spinach has been released by IARI, it claims that it can provide 100% more Vit.C and 15% more β-carotene than the conventional spinach (Sirohini, 1998).

Similarly Arka Suguna is a multi-cut amaranth released by IIHR-Bangalore and the nutritional qualities for 100 g of edible portion is as follows.

	Arka suguna	Control
Protein (g)	1.72	4.0
Phosphorus (mg)	113.20	83.0
Calcium (mg)	459.2	397.0
Potassium (mg)	401.6	341.0
Magnesium (mg)	88.0	247.0
Iron (mg)	48.48	25.5
Oxalate	1.49%	1.97%
(fresh weight basis)		
Nitrate	0.95%	0.90%
(dry weight basis)		

(Varalakshmi *et al.*, 1998)

2) How is leaf concentrate prepared and can it be prepared at house hold level?

The leaf juice is extracted and then curdling done through warming. Then it can be consumed as such or dried into a powder form and incorporated into foods. It can be prepared at house but it will be less efficient because the antinutritional factors like

oxalates, nitrates present in leaves will increase when concentrated but in the case of commercial preparation the antinutritional factors are first removed and then concentration is done.

3) Which is the best cooking method to be followed to increase the bioavailability of micronutrients from leafy vegetables?

In order to retain β-carotene sautéing in 5-10 g of oil is found to beneficial but in case of mineral like Fe, cooking along with acidic foods like Vit. C rich foods in correct quantity of water is recommended. So a combination of methods like first sautéing then cooking in enough quantities of water is found to be beneficial.

4) Out of the leafy vegetables which one is the richest source of β-carotene?

Colacasia leaves.

5) Is glass ware used for cooking?

Yes, example is pyrex glass wares.

ABSTRACT

Leafy vegetables occupy an important place among the food groups as they provide adequate amounts of vitamins and minerals for human beings. Eventhough leafy vegetables are available year around, deficiency of iron and vitamin A exist. One of the factors contributing to this is the poor micronutrient bioavailability from foods.

Bioavailability is defined as the degree to which food nutrients are available for absorption and utilization in the body (Espy, 1977). Bioavailability depends mainly on the chemical form in which nutrients are present, nature of other dietary constituents, stability to cooking and processing, efficiency of individual's digestive system.

The major micronutrients present in leafy vegetables whose bioavailability studies have been carried out are β-carotene, iron, calcium and zinc. Studies suggest that the bioavailability of micronutrients from leafy vegetables are low compared to animal foods. The micronutrients in leafy vegetables are more surrounded by inhibitors like phytates, oxalates, fibre etc. thus affecting their bioavailability (Dokkum, 1992 and Rao, 1998).

Consumption of balanced diet, better cooking practices, substituting conventional leaf vegetables with improved varieties (Bhaskaracharya, 2000) are some suggested methods for improving bioavailability of micronutrients from leafy vegetables.

"PACKAGING OF PERISHABLES FOR BETTER MARKETING"

Report of the seminar presented on 28 th September 2001

Submitted in partial fulfillment of the requirement of the course

PROC-651, SEMINAR

By

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DECLARATION

I, *Sujatha, M.P.*, hereby declare that this seminar paper on *'Packaging of perishables for better marketing'* has been prepared by me independently after going through various references cited herein and I have not copied or adapted from any of my fellow students.

Place:Vellanikkara

Date : 5-11-2001

5/11/01

Sujatha M.P.

2000-12-09

CONTENTS

INTRODUCTION

India can be regarded as a 'Horticultural Paradise'. India has emerged as the second largest producer of fruits and vegetables the world over with an annual production of 40 Million tonnes of fruits (10 percent of world production) and 73 Million tonnes of vegetables (13 percent of the world production) (Dutt, 2001).

But the availability of fruits and vegetables to an Indian is far behind the recommended level.

	Percapita Requirement	Percapita Availability
	(g / day / person)	
Fruits	120	99
Vegetables	285	210

(Dutt, 2001)

So there exists a considerable gap between gross production and net availability. This is mainly due to post harvest loss. The postharvest loss of fruits and vegetables is estimated as 65 Million tonnes valued at Rs 7500 crores each year (Roy and Pal, 2000; Singh, 2001).

The grave situation of post harvest loss can be realised from the findings of Food Ministry of India that we waste more fruits and vegetables than what the U.K. consumes every year (Reddy, 2000). Post harvest loss can be considered as a social evil, which eats up the grower's margin and pushes up the consumer's price. This postharvest loss is mainly due to improper and unscientific handling and packaging being followed in India. In this era of

globilisation we should seriously think of coming forward with ideal packaging of commodities so as to reduce postharvest loss and to compete in the domestic as well as international markets.

PERISHABLES

As per FAO specifications, Perishables are those commodities which have a moisture content of 50 to 90 percent, large unit size of 5 g to 5 Kg or more, high generation of heat, soft texture, brief shelf life from few days to several months and are easily prone to mechanical damages (DasGupta and Mandal, 1989).

Examples for such perishable commodities are Fruits, Vegetables, Flowers, Mushroom etc.

All these characters make them easily vulnerable to postharvest loss.

"Loss"(as defined by FAO and United Nations Environmental Programme) means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people.

POSTHARVEST LOSS OF PERISHABLES

Postharvest loss of perishables may be due to physical, physiological or pathological reasons or a combination of these factors (Toma, Fransler and Knipe. 1990)

A. Physical losses: -Due to injury resulting from poor handling and packing, during transportation and storage or from damage in the market.

B. Physiological losses: - Due to unavoidable endogenous metabolic process like respiration, transpiration, senescence or due to avoidable factors like exposure to adverse environmental factors (eg: - normal temperature of tropics.)

C. Pathological losses: -It is the largest single cause of avoidable postharvest loss. It is due to microbial spoilage as a result of infection by one or more pathogens

eg: - fungi, bacteria etc.

CAUSES FOR POSTHARVEST LOSS. (Kader, 1980)

Group	*Commodity*	Principal causes for loss and poor quality
Root vegetables	Carrot Beetroot Onion Sweet potato Garlic	Mechanical injury Improper handling Sprouting and rooting Water loss (shriveling) Decay
Leafy vegetables	Lettuce Spinach Cabbage	Water loss (wilting) Loss of green colour Mechanical injuries Decay
Flower vegetables	Broccoli Cauliflower	Mechanical injuries Yellowing and other discolourations Abscission Decay
Immature vegetables	Brinjal Okra Cucumber Squash	Over maturity at harvest Water loss Bruising and other mechanical injuries Decay
Mature fruits and vegetables and all fruits	Tomato Melons Citrus Banana Mango Apple	Bruising Over ripeness and excessive softness at harvest Water loss Compositional changes Decay.

Of these principal causes, majority can be overcome by proper and scientific packaging and handling of the commodity and thereby reduce postharvest loss and improve the quality and marketability.

DRAWBACKS OF EXISISTING MARKETING SITUATION OF FRUITS AND VEGETABLES

A) Market infrastructure for fruits and vegetables are generally congested and unhygienic

B) At present fruits and vegetables are being packed in unscientific packaging materials like sacks or bamboo baskets or wooden boxes which are easily prone to spoilage

C) Mainly fruits and vegetables are heaped up for sale. Heaping has certain disadvantages like:

1. High heat build up due to respiration of the commodity
2. More chances of microbial attack and bruising

D) Kept exposed to harsh tropical temperatures which leads to PLW (physiological loss in weight) and loss in appeal

All these highlight the necessity for proper and scientific packaging to ensure better marketing.

PACKAGING

The key functions of Packaging are to:

- Assemble the produce in convenient units for handling
- Protect the produce during handling, transportation, storage and marketing (Wills *et al.*, 1996)

UNIVERSALLY STANDARDISED REQUIREMENTS FOR PACKAGING

- The packages must have sufficient mechanical strength to protect the contents during handling, transporting and stacking one over the other.

- The package must meet handling and marketing requirements in terms of size, shape and weight in accordance with International standards. The current trend is to reduce the many sizes and shapes of packages by standardisation. Palletisation and mechanical handling makes standardisarion essential for economic operation.
- The material of the package must not contain any toxic chemicals, which could transfer to the produce and be toxic to it or to humans.
- The package should allow rapid cooling of the contents
- The package should be stable to moisture and high humidities
- The package should be stackable and interlockable
- The packages should be re-usable or recyclable or easily disposable
- The package should provide adequate ventilation
- Capacity should be suitable to market demands
- It should be cost effective in relation to market value of the commodity

ADVANTAGES OF PACKAGING

Packaging provides a beneficial modified microenvironment that helps in:

- ✓ Minimising postharvest loss by:
  Protecting against mechanical damage, microbes, pests, dust and air pollution, moisture loss, pilferage etc
- ✓ Efficient handling and marketing
- ✓ Giving a better appeal so a competitive advantage which helps to promote sale
- ✓ Providing hygienic condition within the package

- ✓ Enhancing marketable life so previously unreachable markets can be gained
- ✓ Protecting nutritive quality
- ✓ Preventing contamination by other commodities
- ✓ Providing information about the contents
- ✓ Ready to use facility

CLASSIFICATION OF PACKAGING MATERIALS

Traditional ones:

1. Natural materials: Bamboo, Straw, Palm leaves
2. Natural and Synthetic fibres: Sacks: Jute, Cotton, Woven plastic, Paper
3. Wood: wooden crates, Wire bound veneer crates

All these classified as not so efficient

Recent ones:

1. Corrugated fibre board: Ventilated and Nonventilated
2. Plastic crates
3. Moulded Trays: Paper pulp and Plastic
4. Net / Mesh bags /Sleeve packs
5. Plastic films / bags /boxes

Specialised ones:

1. Cling film
2. Shrink wrap film / Stretch film
3. Flexible packaging materials for modified atmosphere packaging: Low-density polyethylene (LDPE), Cellophane, Rubber hydrochloride (Pilo film), Polyvinyl chloride (PVC)
4. Fancy packaging materials: Gift fruit packing

TURAL MATERIALS:

This type of packages includes baskets and other aditional containers made from Bamboo, palm leaves, straw c.

The characteristic features of such containers are:

abour cost and raw material cost involved in making such ontainers are low and they provide good ventilation

rawbacks:

* Difficult to clean if contaminated with decay organisms
* Lack rigidity and bend out of shape when stacked
* Load badly because of shape
* Cause pressure damage when tightly filled
* Sharp edges or splinters cause cut and puncture damage to the contents.
* Less life so should be replaced frequently.

NATURAL / SYNTHETIC FIBRES: SACKS

These types of packaging materials are made from jute or cotton or woven plastics or paper.

They are inexpensive and readily available, moreover they are reusable, and have good load bearing capacity

Drawbacks:

* Lack rigidity and handling can damage contents
* Too large for careful handling, so if dropped it bruises the contents
* Impair ventilation if stacked
* Difficult to stack on pallets

Even though they have these drawbacks they are widely being used in Kerala for bulk packaging and transporting of fruits and vegetables so a modification suggested is

placing a woven bamboo about one meter long to vent the heat developed during respiration.

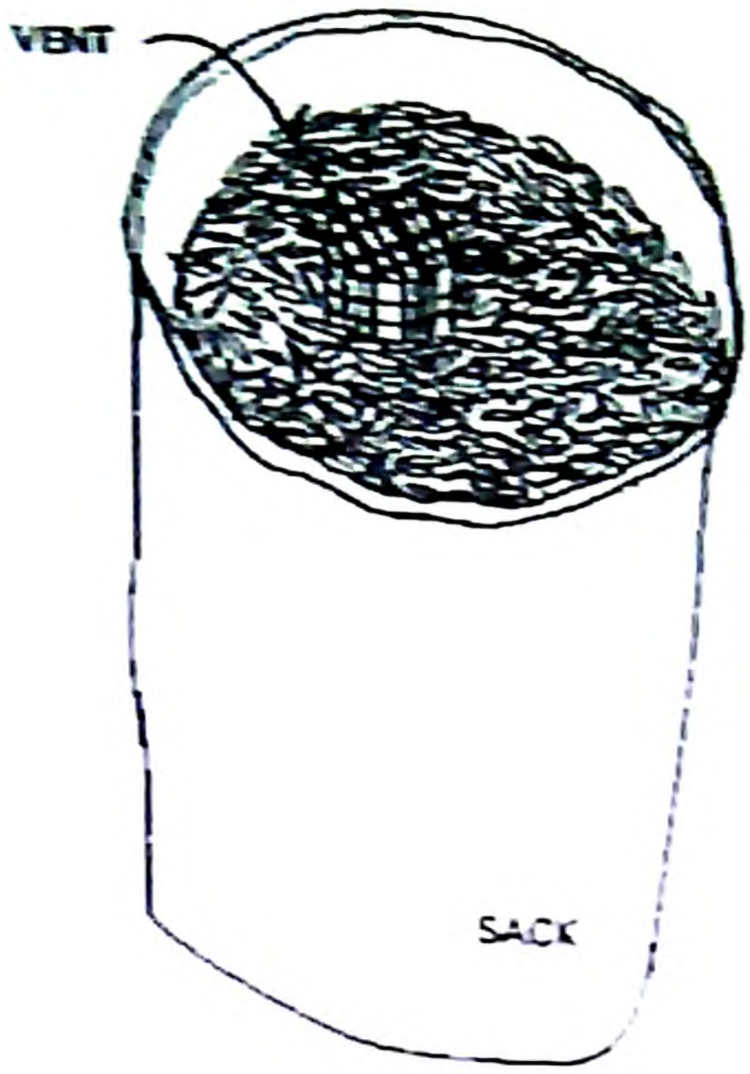

Figure: 1. The addition of a simple vent can help reduce the buildup of heat as the product respires. A tube of woven bamboo about one meter long is used to vent a large bag.

WOOD: CRATES AND WIRE BOUND VENEERS

They are advantageous in the following characteristics like:

- Rigid and durable
- Facilitate good ventilation
- Stack well and may be collapsed to a standard size

Drawbacks:

- Difficult to clean adequately for multiple use
- Heavy and Costly to transport
- Sharp edges, splinters and protruding nails damage contents

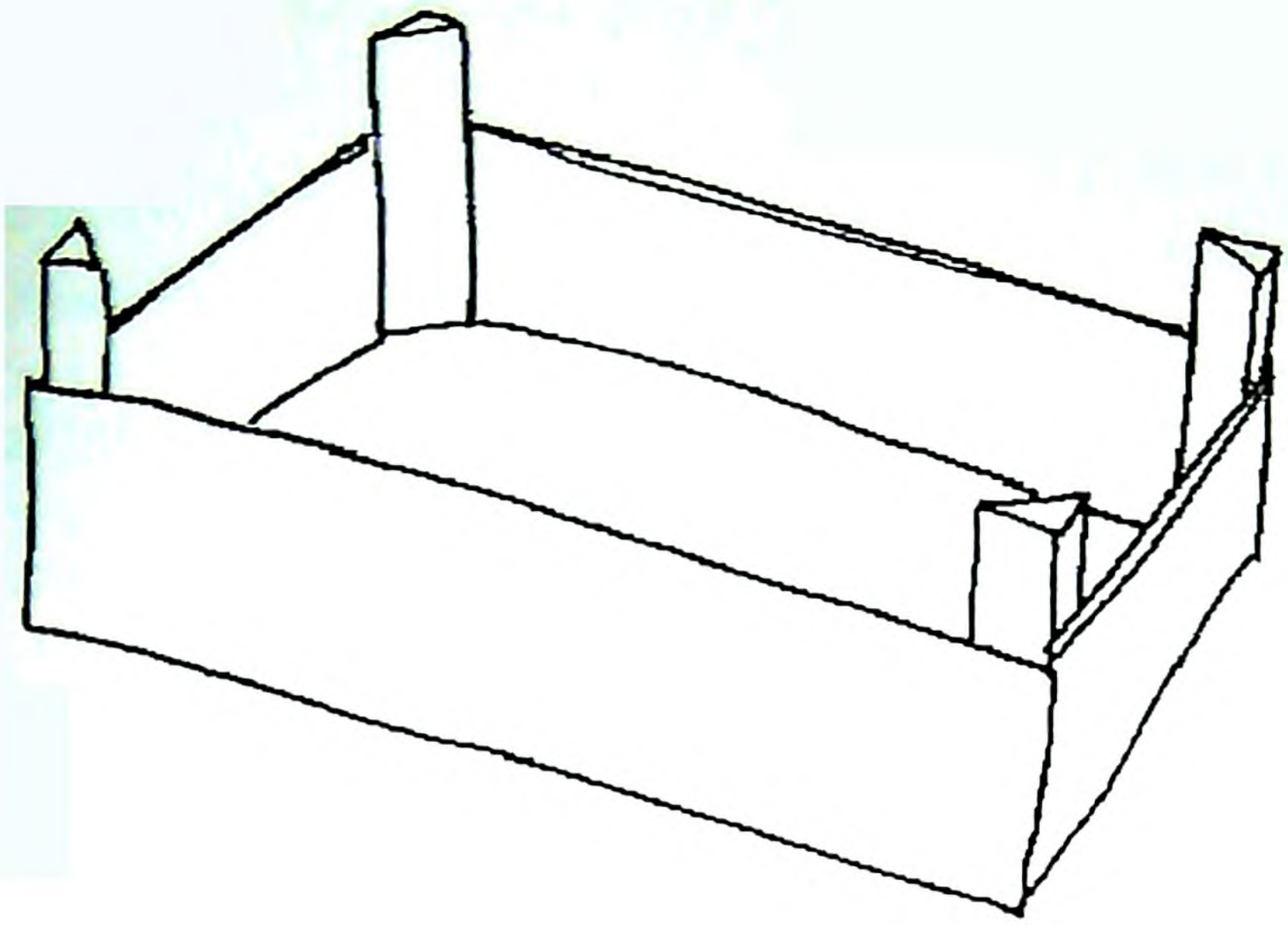

Figure: 2. A simple wooden tray with raised corners is stackable and allows plenty of ventilation for fragile crops such as ripe tomatoes. (FAO, 1985)

CORRUGATED FIBRE BOARD (CFB) BOXES/CARTONS /CASES

Also known as cardboard/fibreboard/pasteboard. It is made from a layer of corrugated fibreboard sandwiched between 2 additional layers of fibreboard. The characteristic features of this most widely used and acceptable packaging materials that made it popular are:

- ✓ Lightweight (20 to 25 percent lighter when compared to wooden box of similar size) and Clean
- ✓ Excellent cushioning property, Smooth nonabrasive surface
- ✓ Low cost, Reusable and Recyclable
- ✓ Excellent printability
- ✓ Easy to setup and collapsible for storage
- ✓ Available in wide range of sizes, designs and strengths

Drawbacks:

- Easily damaged by careless handling and stacking
- Weakens on exposure to moisture

SALIENT RESEARCH FINDINGS: CFB BOXES

CFB is Superior to conventional wooden box for packaging Apple, Mango, Plum etc. Bruising loss when packed in CFB (5 percent) is less when compared to wooden box (30-40 percent) for Apples (Anand and Maini, 1982;Joshi and Roy, 1984)

Sam, 1997 reported that tomato (var:Sakthi and PKM -1) stored under sawdust having moisture content of 35 to 40 percent with a proportion of 1:0.5 (tomato: sawdust) in CFB had a shelf life of more than 21 days.

Nendran coated with 12 percent waxol and 12 percent waxol plus1000 ppm benzimin in polyethylene lined CFB were organoleptically more acceptable than other packages (Gouthami 2001)

Research achievements of AICRP on Postharvest Technology of Fruits & Vegetables: (Maini, 1998)

- CFB with ventilated partitions was found ideal for Alphonso mangoes.
- 5-7 ply CFB with1% ventilation was found suitable for Bananas.
- Apples individually wrapped with different kinds of wrappers and packed in CFB retain better quality.

- Telescopic CFB (20 Kg) with pulp board trays are better substitute than conventional wooden box for Apples.
- Wax treated (250 ppm Benlate) mandarin in ventilated polybags kept in CFB could be stored for 3 weeks at ambient temperature and for 5-6 weeks at 10 ^{0} C.
- Baneshan wrapped in tissue paper and packed in vented CFB had a shelf life of 10 days at room temperature

CFB CARTON FOR CUT FLOWERS

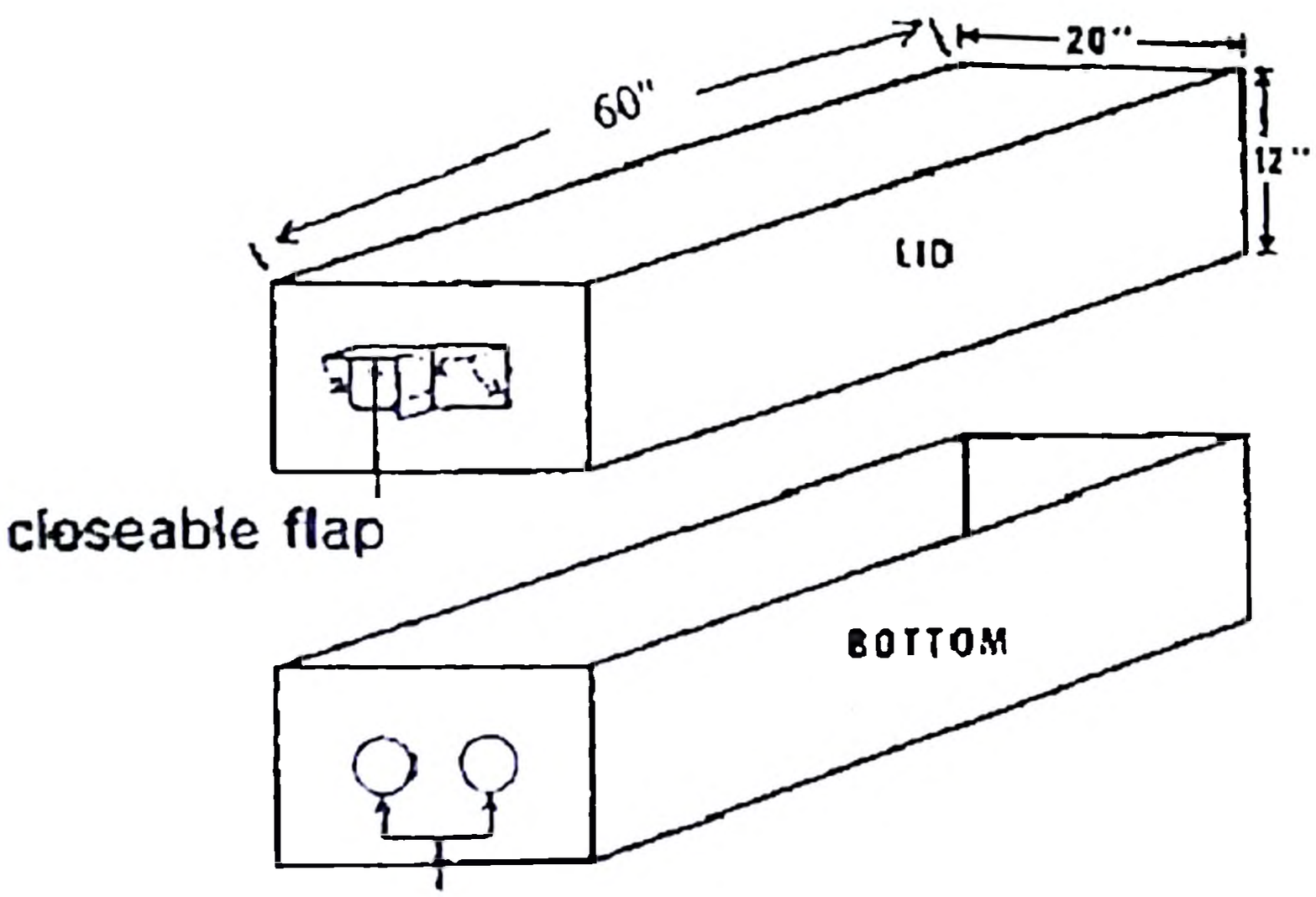

Figure: 3. Long and narrow, full telescopic design CFB carton with vents at both ends to facilitate forced-air cooling. The total vent area should be 5% of the total box surface area. A closable flap can help maintain cool temperatures if boxes are temporarily delayed in transport or storage in an uncontrolled temperature environment. (Rij, 1979)

Figure; 4.Thin paper or plastic sleeves for otecting cut flowers from damage during handling and ansport.

A sleeve is pulled up over a bunch of flowers before cking the flowers into a vented fibreboard carton. The eves both provide protection and help keep the bunches flowers separate inside the box. (Reid, 1992)

Figure: 5.Fibreboard divider: It is used commonly or heavy crops such as melons. It helps to increase tacking strength and prevent melons from vibrating gainst one another during handling and transport. McGregor, 1987)

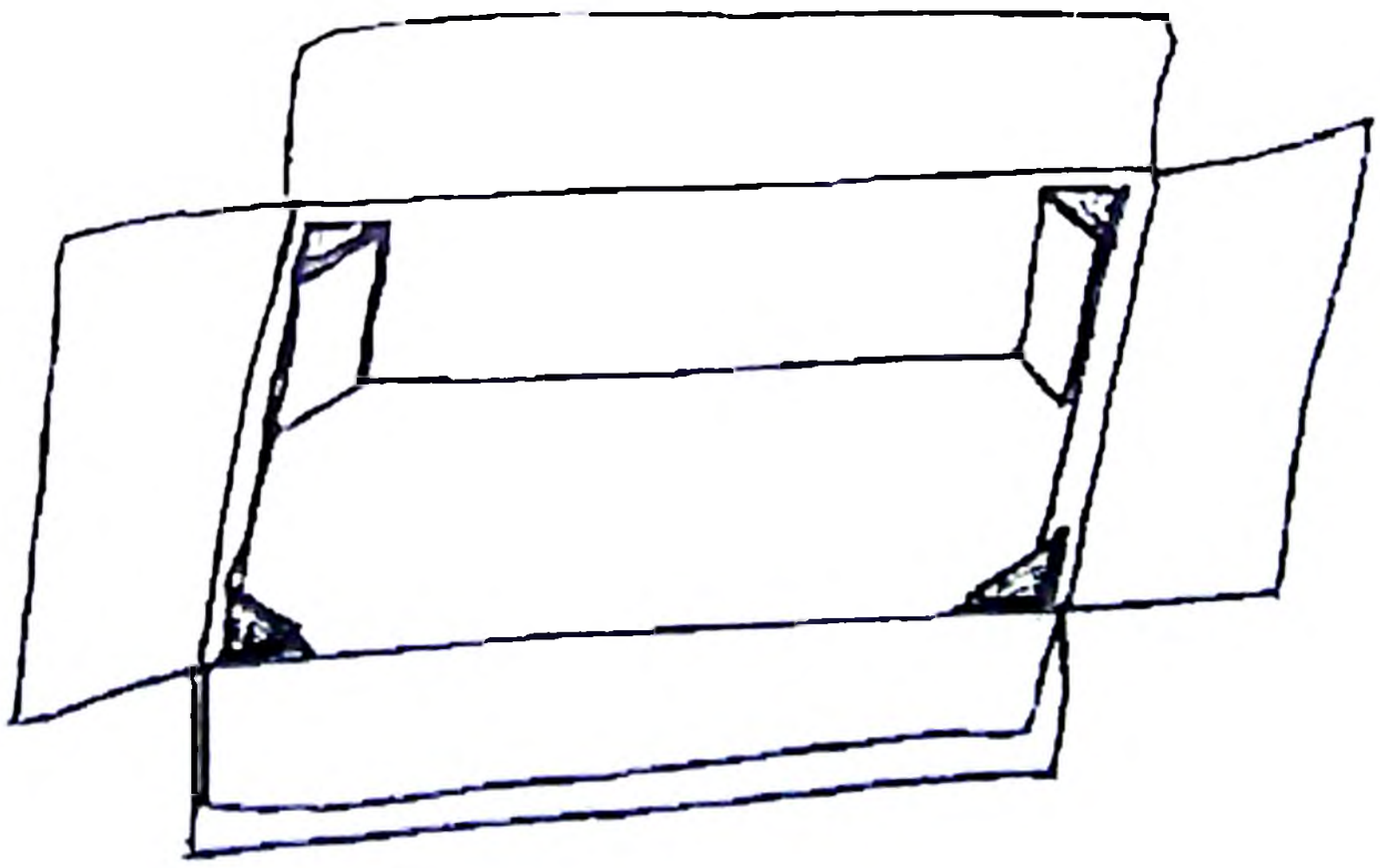

Figure: 6. Triangular corner supports,gives more strength to cartons

PLASTIC CRATES:

They are moulded from High-density polyethylene (HDPE). This packaging material has the following features:

- ✓ Reusable, Strong, Rigid, Smooth
- ✓ Easy to clean
- ✓ Good ventilation
- ✓ Can be made to stack when filled and nest when empty so space saving

Drawbacks:

- * Costly
- * Mostly imported adding to the cost
- * Not foldable
- * Deteriorate when exposed to sunlight of tropics unless treated with UV inhibitor, which adds to cost.

Though costly capacity for reuse make it an economical investment

MOULDED TRAYS:

It may be moulded from paper pulp or plastics. It is suitable for packaging individual fruits or vegetables.

A. Paper pulp:

- ✓ Made from recycled paper and starch binder
- ✓ Inexpensive
- ✓ Absorbs surface moisture from the product so it is good for small fruits and berries which are easily damaged by water
- ✓ Biodegradable and recyclable

B. Thermoformed Plastic Trays

Method of packaging: The produce is filled in trays, over wrapped with a heat shrinkable film and Passed through a hot tunnel

Advantages of thermoformed plastic packaging:

- ✓ Rigid packaging
- ✓ Immobilisation of the produce within the pack
- ✓ Suitable for microwave cooking, without grease and loss of vitamins.

The most commonly used micro-ovenable packages are crystallized polyester (CPET) in the form of trays. They are flexible in shape and design and resistant to oil and greases. Polypropylene co-extruded with barrier resins like Ethyl Vinyl Alcohol (EVOH) is used when a longer shelf life is required (Dordi, 1995)

PLASTIC FILM BAGS

Polyethylene and Polypropylene are mainly used. They have the following characteristic features:

- ✓ Low cost
- ✓ Widely used for consumer size packs in fruit and vegetable markets
- ✓ Retain water vapour and reduce water loss from the contents

Drawbacks:

- * No protection from injury caused by careless handling
- * Heavy build up of condensation may lead to decay
- * Rapid build up of heat if exposed to sunlight
- * Permit only slow gas exchange. Vapour and heat along with slow gas permeability cause rapid deterioration

Consumer packs of plastics are not recommended in tropics except in stores with refrigerated display cabinets

SALIENT RESEARCH FINDINGS: POLYBAGS

- * Polypropylene without ventilation and polypropylene with air blown in, are ideal for oyster mushrooms under such packaging mushroom can be stored for 36 hrs

under ambient conditions and for 10 days under refrigeration (Rama, 1998)

- Non-perforated polyethylene (<100 gauge) was found ideal for White button mushrooms with a storage life of 4-6 days (Gosh et al, 1998)
- Tomato, if packed in Plastic cover with 2 % ventilation plus ethylene absorbent, can be kept for 3 weeks (Sam,1997)
- Mango packed in polyethylene (300 gauge) + ethylene scrubber can be kept for 26 days without any damage. But reduction in Ascorbic acid content and TSS was reported by Kuriakose, 1982
- 100 or 200 gauge polyethylene or polypropylene with 0.5% ventilation was found to be ideal for Brinjal, Chilli, and Tomato and without ventilation for Amaranth, Cowpea and Okra. Storage life was 3 to 4 times more at refrigerated compared to ambient temperature. For packing of PLW and extending marketable life, Portion packing of vegetables (Ash gourd, Elephant foot yam, Bitter gourd pickling melon, Pumpkin, Snake gourd) in polymeric films is ideal (Sunil Kumar, 1994).
- Vacuum packaging of Nendran in 100 gauge polyethylene reduced PLW and increased green life but failed to give optimum ripened quality (Goutami, 2001)
- Better retention of nutrients and longer storage life was reported for Leafy vegetables packed in ventilated PE bags (Maini, 1998)

PLASTIC BOXES

Ideal for consumer packs and has good sales appeal.

T/MESH BAGS

Widely used for packing fruits like apple, citrus, uava, sapota etc. They have the following features:

- ✓ Sturdy
- ✓ Low cost
- ✓ Uninhibited airflow
- ✓ Attractive display which stimulates purchase

rawbacks:

- Large ones do not pallatise well and small bags do not efficiently fill the space inside CFB boxes
- Do not offer protection from rough handling
- Little protection from heat and contaminants

EEVE PACKS (Peleg, 1985)

Heat shrinkable film of 1.5 to 2 mm thickness is used.

he features of this type of packaging are:

- ➢ Immobilisation of [illegible] fruits
- ➢ Superior visibility [illegible] a good sales appeal
- ➢ Low cost
- ➢ Better protection [illegible]

LING FILM

Polyethylene film of 10 microns thickness is used.

Features that make it an ideal packaging material are:

- ➢ Low water vapour transmission rate
- ➢ High gas permeability
- ➢ Intimate package with the individual produce
- ➢ Keeps the produce fresh, dust and insect free
- ➢ Self-sealing types are available commercially.

Studies conducted by Sam, 1997 showed that individual wrapping of tomato with cling film could keep the produce fresh for three weeks under ambient conditions.

SHRINK FILM or STRETCH FILM: (Boyette *et al*, 1999)

Principle involved is plastic films like polyethylene, polystyrene, polyvinyl chloride, polyester, rubber hydrochloride etc have heat shrinkable nature built into them during manufacture. By stretching the film under controlled temperature and tension (creates molecular orientation) the film is wrapped over the produce under this stretched condition by cooling.

The characteristic features are:

- Can be used as over wraps on individual fruits and over consumer size trays or packs
- Shrink on exposure to moderate temperature so make a very tight pack that the packed produce is immobilized
- Heat supplied by electric resistance coils is just enough to shrink the film but not enough to harm the produce
- Mineral impregnated polyethylene film adsorbs and removes ethylene gas and has excellent permeability and good mechanical properties.
- The application of anti-fogging treatment to the film reduces the formation of water drops and the potential for fruit and bacteria growth.

Product benefits

- ✓ Prolongs the life, freshness, and colour of packaged fruits, vegetables and cut flowers.
- ✓ Possible to store and ship ethylene generators and ethylene sensitive products in proximity to each other.
- ✓ The film maintains high humidity levels reducing water loss from packaged produce.

- ✓ The potential for mould and bacteria growth and spoilage is reduced by anti-fogging treatment.
- ✓ A good surface for stick on labels
- ✓ Protects the produce from diseases
- ✓ Reduces mechanical injury
- ✓ Shrink wrapped Lettuce keeps good up to 6 weeks and carnation up to 3-4 weeks (these are classified as highly perishable commodities).

SALIENT RESEARCH FINDINGS: SHRINK WRAPPING

Shrink wrapping (individual fruits as tray over wrap) of mandarins retains natural flavour and freshness upto 3 weeks at 30-35°C (Gosh et al, 1998)

Shrink wrapped breadfruit can be stored for 10 days at 16 ° C without surface browning (Roy, 2000)

Research achievements of AICRP on Postharvest Technology of Fruits & Vegetables (Mani, 1998)

- In banana wrapping with ethylene absorbent extends life by 6 days, Shrink wrapping alone extends life by 4 days under ambient conditions and by 40 days at15 ° C as against 28-30 days in unwrapped control
- Shrink wrapping of Mangoes extend life by 2-4 days under ambient conditions and 6-8 days at 15 ° C
- Pomegranate (Var.Ganesh) can be stored for 3 weeks at 25 ° C and for 10 weeks at 8 ° C by film wrapping
- Shrink wrapped Capsicums shows maximum firmness

ODIFIED ATMOSPHERE PACKAGING (MAP)

Film or plastic materials that "breathes" at a rate ecessary to maintain correct mix of O_2, CO_2 and water apour is used for packing

⇒ When fresh produce is sealed inside a polymeric or plastic film package, respiration will lower the in package O_2 and increases the CO_2 level

⇒ In a well-designed package with optimum permeability the gas levels within the pack will equilibrate in a range beneficial to the produce

⇒ This favourable, unique atmosphere slows metabolic activities to a very low level

⇒ Retains food and nutritional value

⇒ Increases shelf life and market flexibility

⇒ Good for branded, high quality, high value fruits and vegetables and minimally processed vegetables

⇒ Optimum CO_2: O_2 concentrations are product specific and varies with cultivars/genotypes, production area, harvest maturity etc

VANTAGES OF HIGH CO_2 AND LOW O_2 ATMOSPHERE

- ✓ Lowers respiration rate
- ✓ Blocks biosynthesis of ethylene
- ✓ Inhibits growth of pathogens
- ✓ Maintains health and integrity of tissues
- ✓ Prevents chlorophyll degradation
- ✓ Maintain food value, nutritional value and flavour by slowing the loss of food reserves
- ✓ Inhibit the loss of labile vitamins: vitamin C and vitamin A
- ✓ Slows cell membrane degradation and loss of cellular compartmentation and function

✓ Inhibit discoulouration of cut surfaces

Film type	CO_2 :O_2 ratio
LDPE	2.0-5.9
PVC	3.6-6.9
Polypropylene	3.3-5.9
Polystyrene	3.4-3.8
Saran	5.8-6.5
Polyester	3.0-3.5

SALIENT RESEARCH FINDINGS OF MAP

- Sornsrivichai et *al*, 1992 found that ripening was inhibited in modified atmosphere packed mangoes and fruit quality was adversely affected.
- Suitable regimes for modified atmosphere storage of mangoes are 3 to 5 percent oxygen and 5 to 10 percent carbon dioxide at 10 to 15°C. Decreased O_2 delays ripening and increased CO_2 favoured firmness retention (Jordan and Smith, 1994)
- Kader, 1986 found that keeping quality of banana was excellent when stored under modified atmosphere of 2 to 5 percent oxygen and 2 to 5 percent carbon dioxide at 12 to 15 °C.
- CFTRI has standardized slow and quick release inpackage fumigants, which are metabisulphate treated paper packages (Vapour guard) for grapes.
- In papaya film wrap and ecofresh wrap extended storage life up to 15 and 9 days respectively (Gaikwad, 2000)
- In nectarines micro perforated films with inpackage gas level of more than 15 percent carbon dioxide and not less than 4 percent oxygen was adequate to control physiological cold storage disorder (Retmales, 2000)

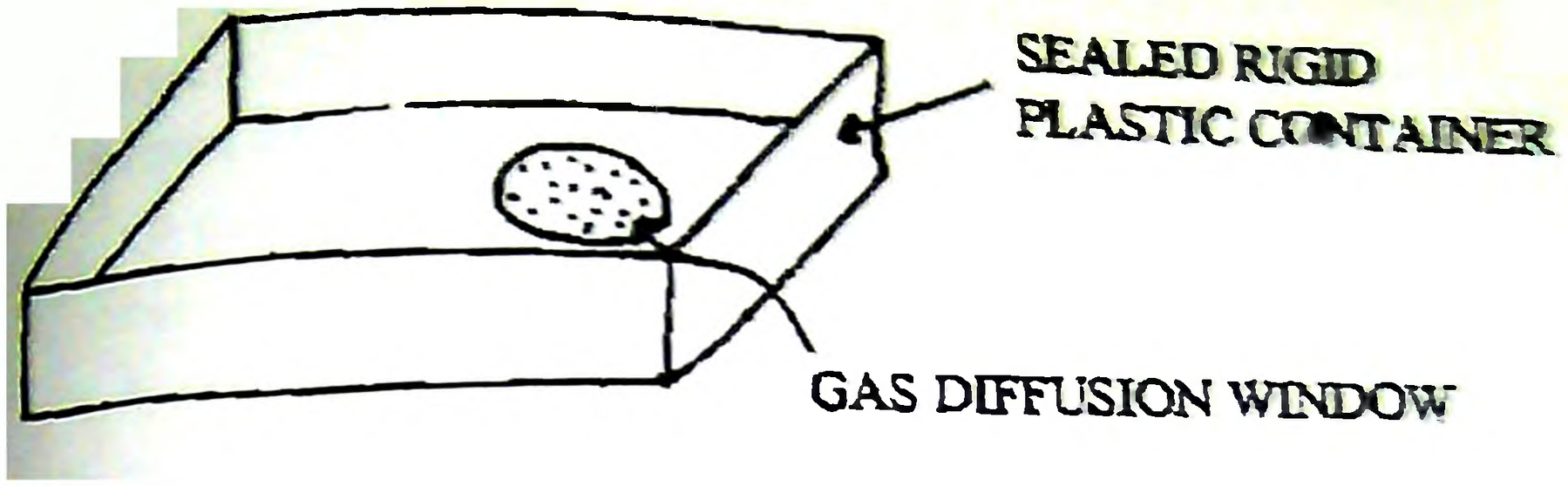

Figure: 7.Modified atmosphere package.

EDIBLE PACKAGING

Lipid, wax, oil coatings, Sucrose esters of fatty acids, Casein plus alginic acid and acetylated monoglycerides, Chitosan plus laurel oils like coconut oil etc are used for edible packaging.

⇒ Lipid coatings on fresh fruits and vegetables retard PLW due to [illegible] of [illegible]

⇒ Wax and [illegible] : Waxes, Esters and Resins (Drake and [illegible] (Paull and [illegible] Cucumber [illegible]

The advantages of edible coatings are :

- ✓ Biodegradable
- ✓ Regulate [illegible] and lipid transfer
- ✓ Imparts mechanical resistance
- ✓ Controls loss of volatile flavour and aromas
- ✓ Act as carriers of fungicidal, bactericidal and antioxidant compounds
- ✓ Individual packaging of Peas, Beans and Strawberries possible that are currently not done due to practical reasons and it provides good lustrous appearance also to the produce.

Two aqueous wax emulsion formulations viz., Waxol-W and Waxol-O were developed at CFTRI (Dalal, et *al.*, 1971).

ANTIMICROBIAL PACKAGING (Tregunno and Tewari, 2000)

⇒ Antimicrobial agents incorporated into packaging films

Eg: - SO_2, Grape fruit seed extract, Nisin, Lysozyme, Allyl isothiocyanate

⇒ They Inhibits Mould and Bacterial growth

ETHYLENE SCAVENGING FILMS

They are more popular than ethylene scavenging sachets, which has limited consumer acceptance. Films impregnated with powdered minerals whose composition is not revealed are available commercially.

- ✓ Adsorbs and removes ethylene
- ✓ Excellent permeability
- ✓ Good deodourising property
- ✓ Antifogging agents reduce condensation of water drops and potential for microbial growth

MAP and ETHYLENE SCAVENGING IN SYNERGY

Combining an optimized gas mix with the use of ethylene scavengers inside packages of high value Fruits and Vegetables is reported to provide a synergistic extension of produce shelf life.

COST EFFECTIVENESS OF PACKAGING

Packaging adds to the cost of marketed produce. But this added value is offset by factors:

- Significant reduction in loss
- Presentation and quality of the product makes it more desirable there by providing a competitive advantage
- Extended market life

However packaging cost must not exceed consumer's willingness to accept the added value of the product, i.e. the extra cost involved.

INTERNATIONAL IMPORTANCE OF PACKAGING

International bodies as well as national governments publish standards for fresh fruits and vegetables. One of these is the secretariat of United Nations Economic Commission for Europe who publishes the UN/ECE standards for fresh fruits and vegetables. These standards are fixed by the working party on standardization of perishable produce. According to these standards presentation of the produce in terms of their uniformity and packaging and information given on the package and where and how it should be presented are inevitable (Thompson, 1996)

CONCLUSION

The three P's associated with packaging are:

Protection : till the produce reaches the consumer

Preservation : till the produce is consumed

Presentation : It is very important in a competitive market. It is a powerful marketing tool and acts as a 'silent sales man'

According to Dr.R.H.M.Murthy, a renowned packaging expert "packaging not protects what it sells and sell what it protects".

So scientific packaging plays a key role in better marketing of perishables thereby minimizing postharvest loss and extending the marketable life of highly perishable commodities like fruits, vegetables, cutflowers, mushrooms etc. The existing practices of packaging of fruits and vegetables in gunny bags, woven baskets and traditional wooden crates result in excessive mechanical damage leading to heavy economic loss. Improved packaging plays an important role in protecting the quality as well as quantity of these perishable commodities and thereby

extending the marketability potential of fruits and vegetables to the advantages of growers, traders and consumers.

DISCUSSION

Q.1.Is it safe to use plastics as it is a potent source of environmental pollution and is there any carcinogenic or toxic effects for plastics.

A.1.Plastics is one of the versatile materials ever discovered. We can't completely do away with plastics. It is ideal as packaging materials in different forms and shapes. So instead of avoiding plastics it is better to use them properly, by implementing laws to collect and recycle plastics.

Plastics are [illegible] polymers are nontoxic and inert, however [illegible] like polystyrene, PVC and polyacylonitrile are [illegible] health. Before using any plastic [illegible] permission has to be obtained [illegible] Government of India. [illegible] unreacted monomer [illegible] of monomer per [illegible] of polystyrene and [illegible]

Q.2.How the grape guard [illegible] within a grape package

A.2.Sulphur releasing compounds like KMS or sodium meta bisulphate impregnated over vermiculite or silica are wrapped in paper sachets and kept over packaged grapes. Moisture released due to metabolic activities of grapes wets the paper sachets and this leads to the release of sulphur gas from the sachets.sulphur gas being a heavy gas

sinks to the bottom and thus protects the packaged grapes from microbial spoilage especially that of wild yeast.

Q.3.How packaging is useful in low temperature storage

A.3.Packaging helps to avoid chilling injury of the produce by providing a modified microenvironment. The produce is saved from chilling injury as it is protected by the package from direct contact with chilling temperatures of low temperature storage.

ABSTRACT

Though India ranks second in the World for the production of Fruits and Vegetables, a wr gap still exists between the per capita requirement and availability (Attavar, 2000) One of the major reasons attributed to this is the heavy post harvest loss incurred, which is estimated to the tune of 30 to 40 % of the total production accounting to an amount of Rs 7500 crores per annum (Roy and Pal, 2000; Singh, 2001). Post harvest losses are mainly due to the improper and unscientific handling, lack of infrastructure and poor packaging techniques prevailing in India. In the present context of globalisation it is high time to switch over to scientific handling and proper packaging of the perishables to compete both in the domestic as well as in the international market.

Perishables include fruits, vegetables, mushrooms and flowers. Owing to heir peculiar nature, they are proved to be susceptible to physical, physiological and pathological damages (Dasgupta and Mandal, 1969).

Sorting, grading and scientific packaging to a great extent can overcome such losses and improve quality and marketability of the perishables.

Existing market infrastructure are either congested or unhygienic, resulting n an unaccounted loss to such a high valued commodity.

Selection of ideal packaging materials as well as scientific packaging echniques can enhance marketing and over all quality of these produces Tregunno and Tewari, 2000)

Therefore packaging provides a beneficial and modified environment that ielps to enhance the market life of these perishables by reducing the mechanical njury, slowing down the metabolic activities like transpiration, respiration and enescence, and protecting them from microbes, pest and dust pollutions urthermore attractive packaging is a powerful marketing tool as it acts as a ilent 'sales man' .

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QUANTITATIVE AND QUALITATIVE CHANGES DURING RIPENING OF BANANA

By

Ramesh.A
(2000-12-20)

SEMINAR REPORT

Submitted in partial fulfilment of the requirement of the Courese Proc.651, SEMINAR

DEPARTMENT OF PROCESSING TECHNOLOGY
COLLEGE OF HORTICULTURE
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DECLARATION

I, A. RAMESH, hereby declare that this seminar report entitled "QUANTITATIVE AND QUALITATIVE CHANGES DURING RIPENING OF BANANA" has been prepared by me independently after going through the various references cited herein and that I have not copied from any others.

Vellanikkara

19-10-01

A. RAMESH

2000-10-20

CONTENTS

1. Introduction

Banana is a important tropical fruit crop in the world trade. Purely in the area of 3,916.13 thousand ha with the production of 65 m.t. In India banana is grown in the area of 445 thousand ha with the production of 11.0 m.t. It contributes 3% of world production (FAO, 2001). In Kerala area of banana is 84.64 thousand ha with the production of 793.31 thousand tonnes (Farm Info., 2001).

The unique feature of banana cultivation in Kerala is its varietal diversity with Nendran occupying to prime position other varieties like Poovan, Palayankodan, Kadali, Njalipoovan and Pachabale figure in the list of table varieties. Mysore, Ethakka etc. grown extensively for culinary purpose.

[illegible] at post harvest behaviour [illegible] scientific [illegible] post harvest [illegible] have [illegible] qualitative [illegible] different [illegible] chosen [illegible] quantitative [illegible] banana fruit.

RIPENING

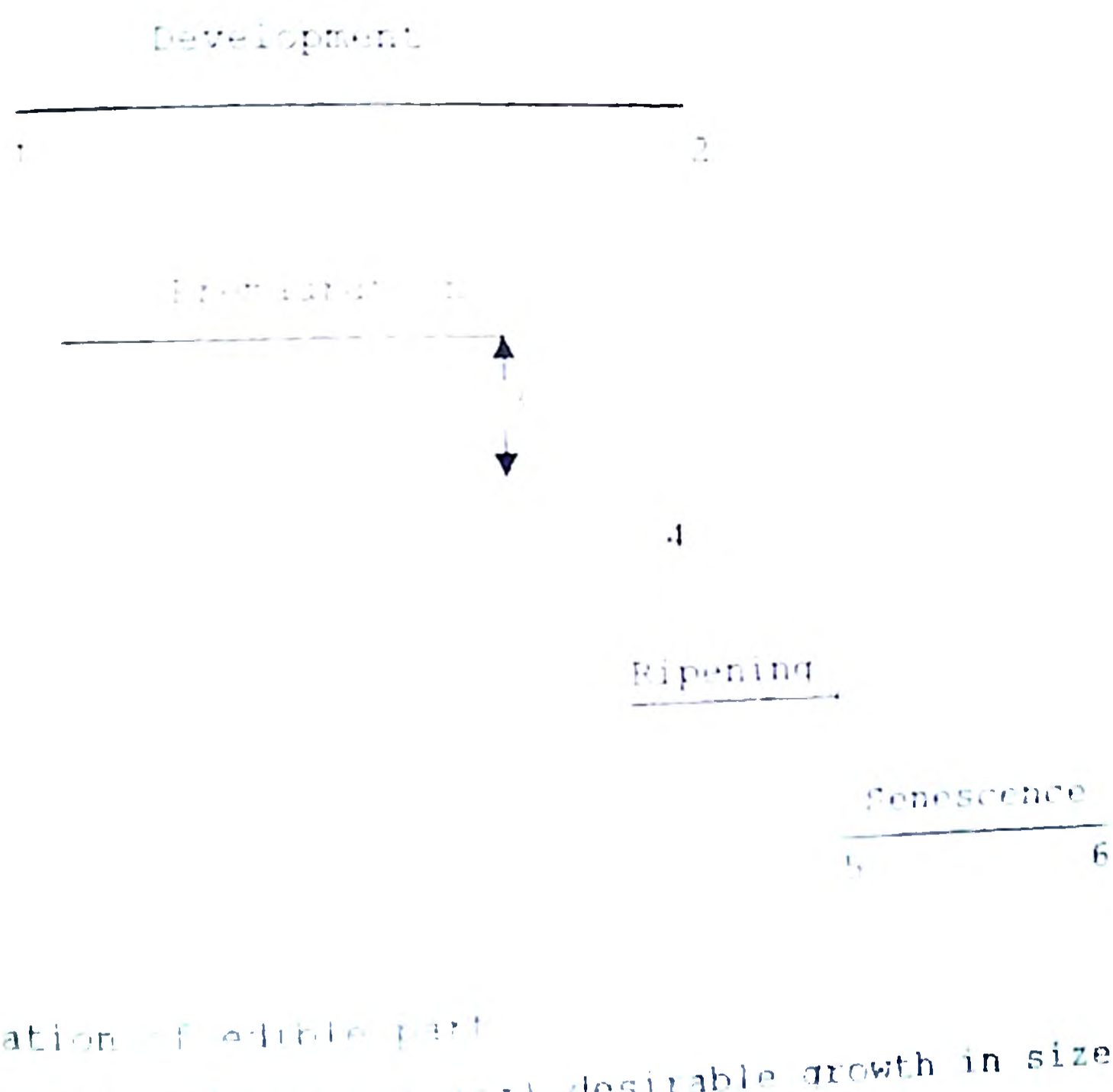
Ripening is the [illegible] between late maturation and early senescence. Ripening is a final phase in the development of fruit and appears to be a co-ordinated process of biochemical differentiation.

The diversity of metabolic shifts, which are specific to a particular commodity, are manifested in

several events like rooting, ripening, sprouting, scalding, yellowing etc. These diversified visible physiological changes may be desirable or undesirable and constitute a most important physiological process called ripening.

Ripening changes, apart from some exceptions, can be clearly detected following harvest and greatly influence the eating quality and the monetary value of the commodity.

Stages during lifespan of fruit (Banana)



1. Initiation of edible part
2. Termination of natural (or) desirable growth in size
3. Start of period of usefulness, but two immatures
4. Period of most usefulness
5. Degradative changes become predominant
6. End of usefulness for human consumption

While banana fruit remain attached to the plant they continue to develop and accumulate starch in the pulp. Increase in finger length continues until about 80 to 90 days after flowering. When fruit maturation begins. At this stage, fingers stop elongation but they continue to increase in width until the fruit is harvested. If left beyond the "commercial [illegible]" stage. The fingers become fully round and [illegible], eventually splitting longitudinally while still [illegible]. Harvesting is required to terminate physical maturity at the required stage.

A harvested banana fruit passes through three physiological [illegible] namely

(1) Pre climacteric [illegible] stage

(2) The climacteric [illegible]

(3) The [illegible]

Pre climacteric (or) green life stage

It represents [illegible] harvest until the initiation [illegible], it is a period of low metabolic [illegible] the commercial objective is to prolong [illegible] as possible.

[illegible] main ways:

(1) Inducing [illegible] inherently long green life with proper harvest management.

(2) Harvesting at [illegible] fruit maturity.

(3) Low temperature [illegible] during transport of packed fruit.

Climacteric

All fruits produced ethylene but in climacteric fruits like banana there is a rapid and massive increase in ethylene production which proceeds the respiratory

climacteric. After triggering the initial rise in respiration, ethylene production decreases again.

The respiratory climax is identified by rapid oxygen uptake and carbon-di-oxide evolution to a maximum rate of 250 mg Co_2 kg^{-1} h^{-1} from a pre-climacteric low of around 30 mg Co_2. The time taken to reach this maximum from the pre-climacteric state depends on temperature humidity and ethylene concentration and the ripening process is accelerated when the respiratory maximum is attained. Subsequently, the respiration rate decreases progressively to reach zero at the physiological death of the fruit.

Harvest maturity

A fruit is ... ripens and ready for harvest when it is at the ... physiological development. The time ... with the variety and climate. ... at harvest is of little importance, ... market weather the fruit is ... distant market. For local ... fruit ... harvested ... that ... work ... 1975).

Getting ... important which resulting ... good palatable fruit. The ... maturity indices are followed

Maturity Indices

Degree days

Maturity can be predicted from temperature data, since rate of fruit maturation from shooting depends on temperature where moisture is not a limiting factor. The use of degree days is not significantly accurate by itself in predicting harvest dates for commercial purposes.

Shoot to harvest records

The number of days from flower emergence to maturity is based on the physiological age. When bunch is harvested by grade alone without knowing the age (time form bagging to harvest), a mixture of fruit differing in age by as much as 50 days can be present in the same box thus leading to risk of 'r-pus' in transport. For an age-grade control programme, it is necessary to have some data on days from shooting or bagging to harvest throughout the year. For this tagging is done with various coloured ribbons on the pedicel. After the required number of days from bagging, all bunches with fruit corresponding to the designated weeks colour is harvested [illegible] and Lumsden, 1997).

Angularity of fingers

Fruits [illegible] fruits with clearly visible [illegible] their maximum size, full three-fourths [illegible] different angles of full stage [illegible] gradually disappeared. However, [illegible] importance of angularity [illegible] there is little agreement [illegible] phase such as 'light full' [illegible] to have the same meaning in [illegible] 'fullness of fingers' is not [illegible] kind cultivars that remain angular even [illegible] maturity (Anon, 1988).

Caliper-grade

For the export [illegible] maturity requirement depend on the specifications provided by the importing countries calibration size and length of finger are the most commonly used indices. For determining caliper grade the middle finger in the outer whorl of the second hand is callipered at the thickest part of the fruit. The grade is expressed

in three ways depending on the country total thirty-seconds of an inch, the number of thirty-second of an inch above thirty-two or in millimeters. The former is used a central and South America, while millimeters are used in Caribbean and Africa. Fruits with calibration of 40/32 to 48/32 are considered mature for harvest (Anon, 1988).

Montoya *et al.* (1984) worked out the correlation between postential green-life and either caliper grade at harvest or age at harvest and found higher correlation coefficients with the age than with calipe grade with potential green-life of hand varying between 18 and 53 days. Adopo *et al.* (1988) reported that yield quality and marketing value of the product were higher with longer periods between fruit set and harvest.

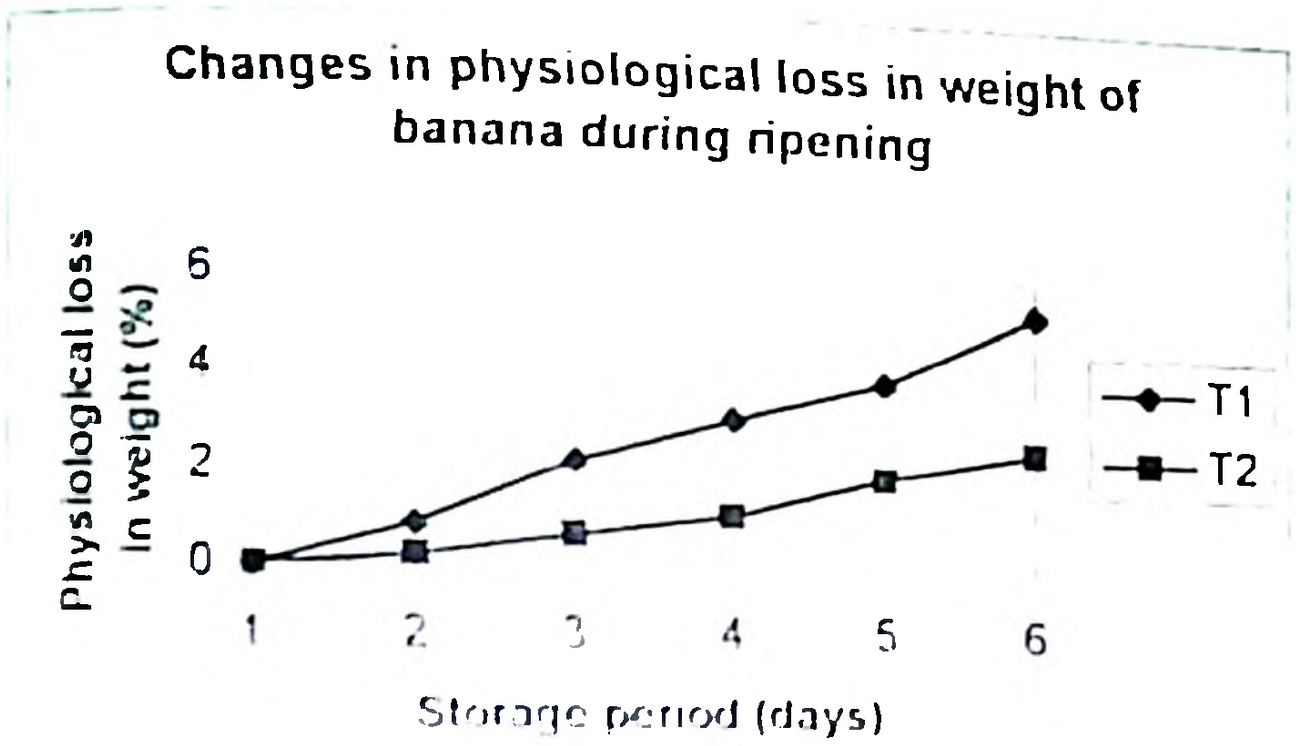
2. QUANTITATIVE CHANGES

Physiological loss in weight

The difference in weight of the fruit immediately after harvest and [illegible] per cent ripeness was divided by the [illegible] of the fruit and expressed as percentage to [illegible] the weight of the fruit there by [illegible].

The physiological loss in weight varied from 4.63 to 29.17 per cent. Shivashankar (1990) reported that loss of water through transpiration appears to be the most important component accounting for the loss of weight. In varieties like Nendran, Palayankodan and Robusta the PLW ranged from 4.63-6.37 per cent and in varieties like Karpooravally, Red banana, Kunna, Njalipoovan, Kadali and Kanchikela the PLW varied from 7.72 to 14.80 per cent.

Data on the cumulative PLW due to transpiration and respiration processes in T_1 and T_2 are given below. Banana fruits in T_1 showed a maximum loss of 5% on the 5th day of storage. On the other hand, fruits in T_2 showed only 2% PLW on 5th day of storage suggesting a limited loss in PLW to fruit in T_1 factors affecting the PLW.



1 - Naturally ripened, artificially ripened

actors affecting the PLW

1) Temperature

2) Relative humidity

Here temperature and relative humidity is having indirect LW. Where as in relationship with elationship. Pantastico and Wachar et al. (1993) they have roved the above hypothesis by storing of the Basrai ariety. In normal room temperature (15-24°C) and the RH 26-90%) the PLW was very high, where as in cool chamber 14-18°C) and the RH (75%) was low. So that indicates if he temperature increases the loss in weight also ncreases.

PHYSICAL CHARACTERS

Changes in physical characters of different varieties of banana during ripening

Characters	Bhos		Basrai dwarf		Basrai	
	Mature	Ripe	Mature	Ripe	Mature	Ripe
Length	19.07	19.07	17.18	17.18	15.0	14.97
Girth	16.62	16.60	11.08	11.09	9.91	9.93
Specific gravity	0.90	0.90	1.03	0.99	0.99	0.97
Pulp/peel	1.26	2.51	1.31	2.39	1.14	2.97

(Tripathi, 1981)

Tripathi et al. (1981) reported the changes in developing banana fruits. Three different varieties of banana viz., Bhos, Basrai dwarf, Basrai grown under agroclimatic conditions of Uttar Pradesh were harvested at maturity and studied for physiochemical characteristics. The stage of full maturity and ripening at which it was observed that the weight of fruit was associated with the circumference. There was no substantial change in the physical characters except pulp to peel ratio which increased during ripening.

Pulp/peel ratio

After peeling the fruit, pulp and peel was weighed on an analytical balance and the weight was recorded in grams. The pulp/peel ratio was calculated by dividing the weight of pulp by the weight of the peel.

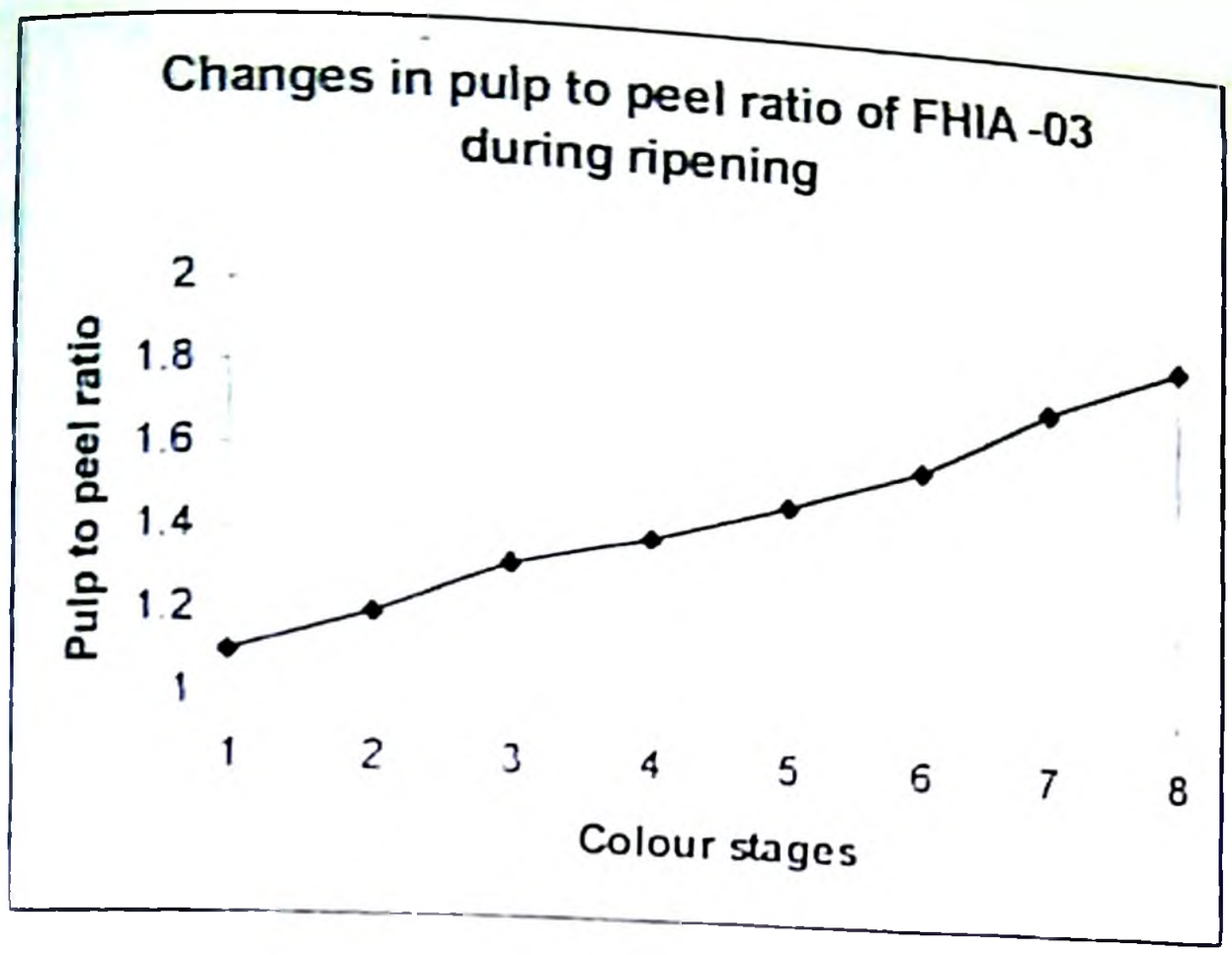
This is very useful technique for estimating the stages of fruit growth in experiments. The pulp:peel ratio Pp increases as the fruit grows because pulp growth increases exponentially but the growth rate of peel begins

to decline, when the pulp:peel ratio reaches 0.5 the fruit is able to ripen. Fruits is normally harvested when Pp is about 1.2 to 1.6.

The pulp/peel ratio of the ripe stage ranged from 1.86 to 8.33. Kadali was having the highest pulp/peel ratio. These values were similar to the values obtained by Ngalani *et al.* (1998).

According to John and Marchal (1995) there was significant increase in the pulp/peel ratio of all banana varieties on ripening. This increase in pulp/peel ratio is due to the water [illegible].

This [illegible] in the pulp to peel ratio during ripening [illegible] cooking bananas. The pulp to peel ratio increased [illegible] progressed and there were significant [illegible] the ripeness stages (P<0.001) [illegible] pulp ratios reflects to different [illegible] the moisture content of these [illegible] during ripening are related [illegible] both tissues. During ripening, [illegible] more rapidly in the pulp [illegible] differential change in osmotic [illegible] water both by transpiration [illegible] to the pulp, leading to an [illegible] weight of the pulp as the fruit ripens. [illegible] an increase in the pulp to peel ratio during ripening.



Moisture (water)

The most abundant constituent of banana fruit is water. The pr[illegible] water and that of unripe plantain [illegible] but there are larger differences between [illegible] in the water content of the pulp, ranging from 70 to 82 (Marchal et al., 1988).

As the fruit ripens, water is lost from the peel due to

(1) A three fold increase in transpiration rate

(2) Water is transported to the pulp from the peel to the pulp

This difference in water potential between peel and pulp is considered [illegible], but it does not necessarily indicate that any water flows from the peel to the pulp. Indeed, if water flowed in response to such a large gradient the peel might dry out completely during ripening, but it does not. This is because volume of low, will respond to the gradient in turgor pressure, Δp gradient in osmotic potential, $\Delta\pi$.

According to Thajudeen *et al.* (2000) the nutrient content of the banana varieties in the ripe stage varied

from 61.00 per cent to 77.23 per cent. The highest moisture content was observed in Red banana and lowest in Njalipoovan. But the moisture content of raw banana varieties ranged from 61.93 per cent in Nendran to 71.97 per cent in Robusta.

Moisture content of banana varieties

Sl.No.	Varieties	Raw	Ripe
1	Nendran	61.93	62.43
2	Palayankodan	68.87	74.43
3	Karpooravally	64.37	67.67
4	Monthan	68.83	74.70
5	Robusta	71.97	76.60
6	Red banana	66.83	77.23
7	Kunnan	63.10	63.10
8	Njalipoovan	61.00	61.00
9	Padali	66.43	66.43
10	Mysore	66.37	66.37
11	Karuthakodan	66.70	66.70

Moisture content of the selected raw and ripe banana varieties was estimated by the method of A.O.A.C. (1980).

Carbohydrates

Starch forms about 20 per cent of the fresh weight of the pulp of unripe bananas. During ripening this starch is degraded rapidly and sugars, sucrose, glucose and fructose accumulate; traces of maltose may also be present (Palmer, 1971).

During early stage of ripening, the rabio of sugars is about 65:20:15 (sucrose:glucose:fructose). This indicating that sucrose appears first, and hexose sugars later

(glucose and fructose). This conversion of starch to sucrose is at a maximum two days after the ethylene peak.

The peel tissue also contains starch, about 3% fresh weight. The physical and chemical properties of banana starch have been investigated by Kayisu and Hood (1981). Who noted that banana starch has an amylose content of 16%, with granules generally of 20-60 µm in size.

Enzymes for both hydrolytic and phosphorlytic breakdown of starch have been identified in banana. Starch degrading enzymes isolated from bananas.

Enzyme	Mode of action	Reference
α-amylase (Ec 3.2.1.1)	Endo, acting on α 1-4 glucose linkages	Young etal. (1974)
ß-amylase (EC 3.2.1.2)	Exo, acting on α 1-4 [illegible] at the non-reducing end of [illegible]	Garcia and Lajolo (1988)
α1,6-glucosidase (EC 3.2.1.[illegible])	[illegible]	Garcia and Lajolo (1988)
Phosphorylase (EC 2.4.1.[illegible])	[illegible]	Yang and Hu (1988) Arcas and Lajole (1991) Kumar and Sanwal (1992)

According to Nanlal et al. (1999) the starch content of the pulp significantly decreased from stage 1 to 5 while the reducing sugar content of the pulp significantly increased.

Jhagudeen (2000) conducted the study on starch content of the banana varieties, that shows the starch content

varied from 0.09 g 100 g^{-1} in Red banana to 2.77 g 100 g^{-1} in Kadali.

Starch content of banana varieties (g 100 g^{-1})

Sl.No.	Variety	Raw	Ripe
1	Nendran	12.09	1.84
2	Palayankodan	8.05	1.77
3	Karpooravally	12.78	1.39
4	Monthan	10.00	1.11
5	Robusta	9.43	1.25
6	Red banana	10.08	0.98
7	Kunnan	10.33	2.69
8	Njalipoovan	13.27	2.74
9	Kadli	11.90	2.77
10	Matti	14.24	2.30
11	Kanchikela	7.70	1.80

According to [illegible] starch and pectic fractions degraded in the pulp of ripe fruit pulp. The significant [illegible] in the hydrocysates of water soluble polysaccharides and that of xy[illegible] hemicellulosic fraction (Hem A) [illegible] mannosed glucan and xylam degradation [illegible].

The carbohydrases hydrolases polygalacturonase, pectin methyl esterase pectinesterase and xylanase (xylam endo -3 beta-xylosidase, laminarinase, alpha-mannosidase, beta-galactra sidase, amylase, cellulase and hemicellulose) generally increased in activity with ripening low levels of endo-beta-mannase and galactanase activities were detected only at the climactric stage of ripening.

According to Hubbard et al. (1990) the primary product of starch breakdown in bananas appears to be sucrose,

followed by hexose accumulation. This sucrose can be synthesized from glucose^{1}-phosphate by converting it to uridine diphosphate-D-glucose (UDP-glucose).

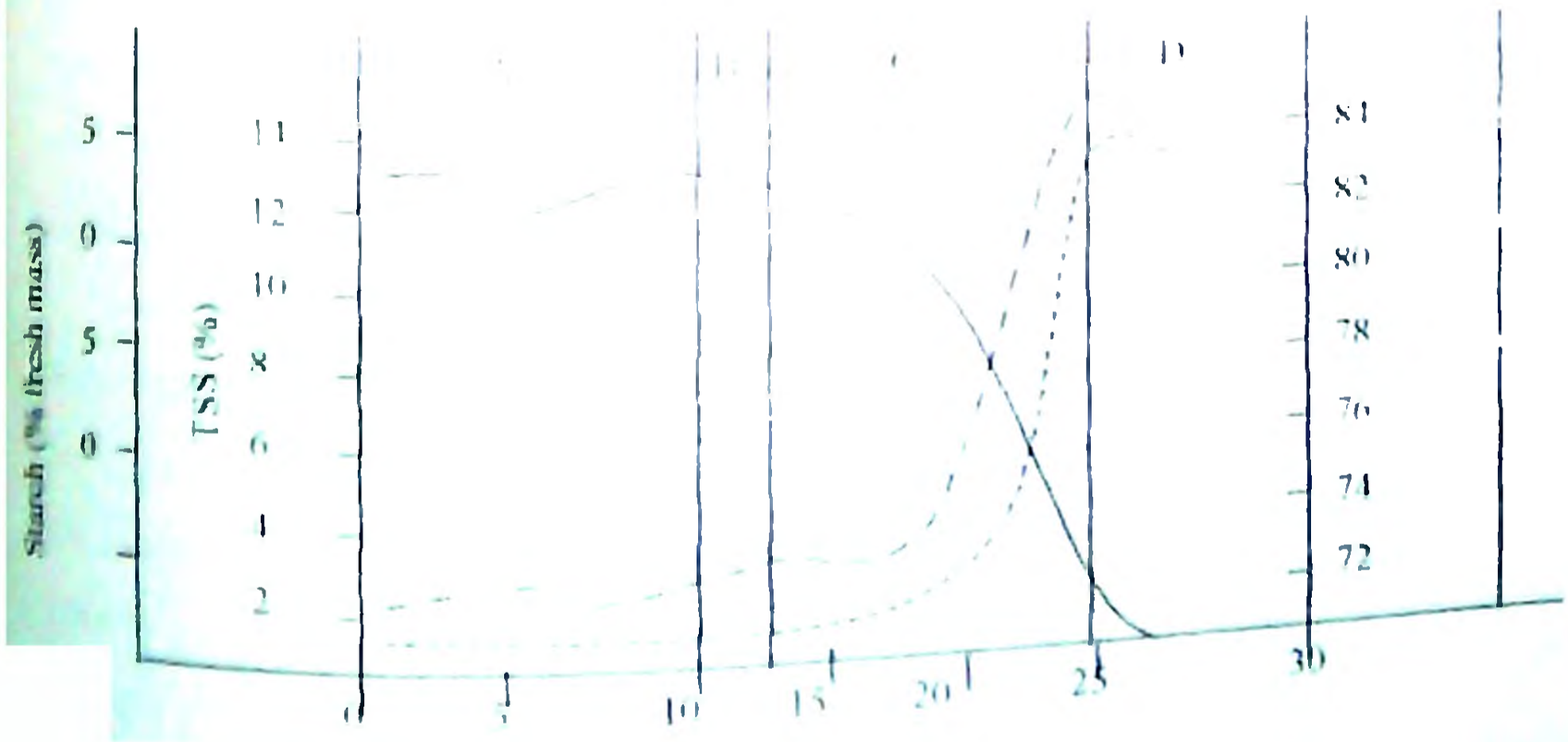
UDP-glucose+fructose-6-phosphate ⟶ sucrose phosphate

Sucrose phosphate synthase

Sucrose phosphate + UDP ⟶ Sucrose + Pi

Phosphatase

The activity of the starch and sugar content and sucrose phosphate synthase (sps) and sucrose synthase (ss) in banana fruits (cv. Manicao) ripening. Starch concentration was higher on the outer than in the inner part of [illegible]. The rate of starch degradation during ripening was similar in both parts, resulting in a [illegible] of residual starch in the [illegible] and accumulation occurred at the [illegible] and coincided with the maxima [illegible]. sps and ss were uniformly [illegible] pulp of both green and ripe fruits, [illegible] distribution between colour development [illegible].



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Changes in the starch, tss and water content in the pulp of 'Giant Cavendish' banana, during the predimacteric, climacteric and ripening stages, A = preclimacteric, B - climacteric, C - ripening (fruits change from green to yellow and start softening), D = eat-ripe stage.

Proteins

The proteins content of a ripe banana amounts to only about 1.1% of its total composition. This comprises some important essential amino acids such as lysine. In the pulp of Cavendish banana, the total free amino acids increases from 330-750 mg 100 g⁻¹ fresh mass when green to 2700-3500 mg 100 g⁻¹ at the ripe stage. Histidine, asparagine and glutamine are the predominant amino acids at the full ripe stage.

Protein [illegible] cv. Dwarf [illegible] analysed [illegible] revealed [illegible] Two polypeptide [illegible] fruits were [illegible] western blotting [illegible] polygalacturonase [illegible] protein groups [illegible]

The protein [illegible] approximately [illegible] pattern of protein synthesis has been studied in ripening bananas, no conclusive evidence was obtained for any massive synthesis of new proteins to coincide with the onset of ripening. However, it may be possible to extend these investigations using molecular techniques.

There is not much variation in the protein content of varieties like Nendran, Kunna, Montha, Poovan and Palayankodan (KAU, 1993). Dube (1988) observed that ripe banana has 1.2 g of protein. It crude protein content of two varieties of cooking banana was found to be 3.2 per cent (Suntharalingam and Ravindran, 1993).

Acids

Although the development of sweetness is important, the overall fruit flavour is also influenced by organic acids. These help form the desirable sugar-acid balance necessary for a pleasant taste. During ripening the acidity of the fruit generally increases. The main organic acids present are malic, citric and oxalic. The sugar:acid ratio increases from [illegible] in green fruit to 100-190 in ripe fruit, depending [illegible].

The astringency [illegible] bananas is probably attributable [illegible] their oxalic acid content, when under [illegible] during ripening, probably by [illegible].

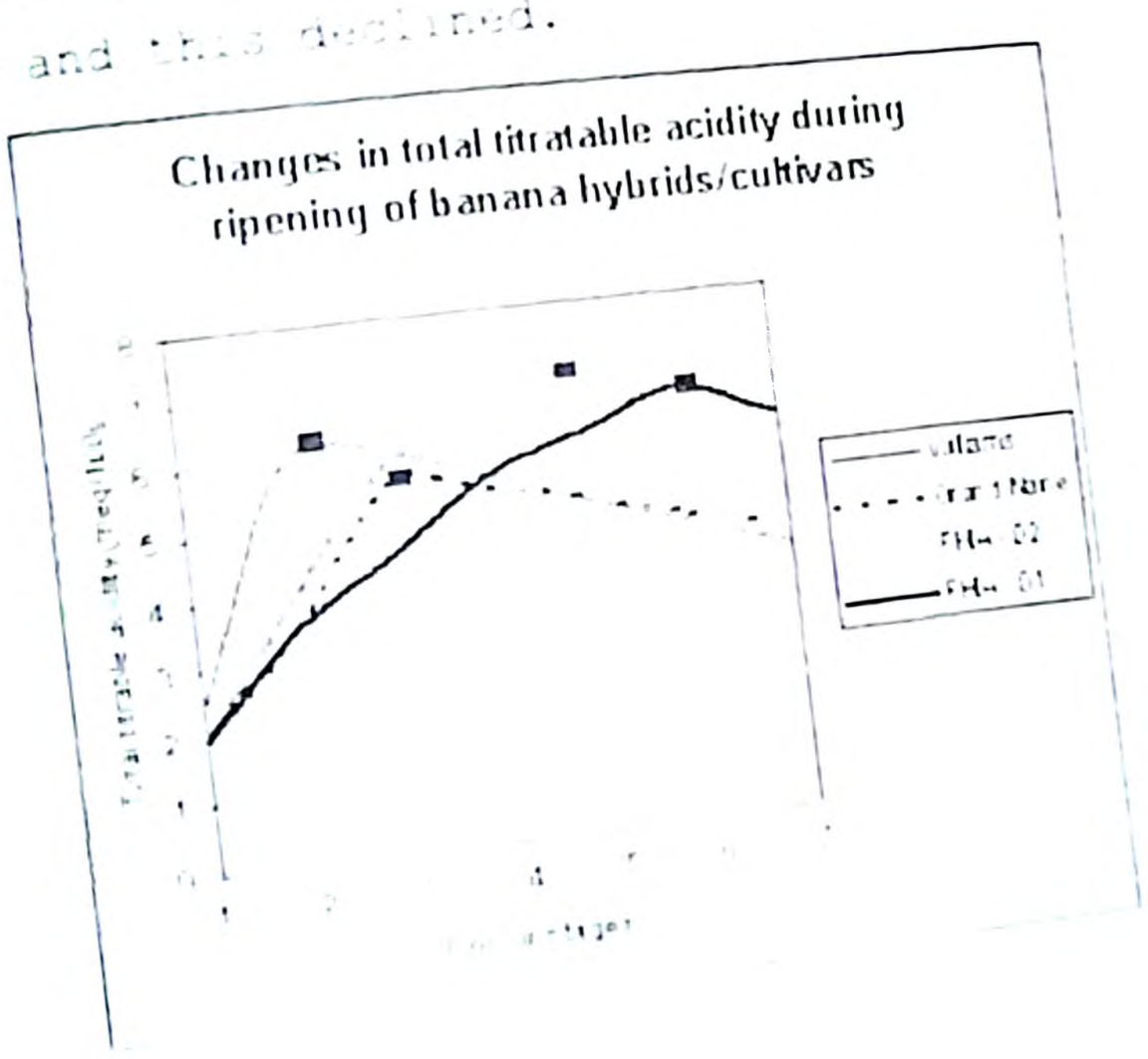
The values [illegible] varied from 0.15 to 1.44 per cent. The [illegible] was observed in Karpooravally and lowest in [illegible].

Acid content [illegible] (Thamilselvi, 2000)

Sl.No.	Variety	Ripe
1	Nendran	0.15
2	Palayankodan	0.51
3	Karpooravally	1.44
4	Monthan	0.19
5	Robusta	0.17
6	Red banana	0.27
7	Kunnan	0.56
8	Njalipoovan	0.24
9	Kadali	0.20
10	Matti	0.24
11	Kanchikela	0.19

The enzymes involved in amino acid metabolism in ripening of banana fruit are glutamate oxaloacetate transaminase and glutamate pyruvate decarboxylase.

Organic acids are essential for maintaining the sugar-acid balance, thus providing a pleasing fruit taste during ripening, Acidity (titrable acidity in FHIA-01 and FHIA-02 pulp tissues increased as ripeness progressed to a peak at colour stages 6 and 5 respectively and then declined. In contrast, Grande Naine and Williams, trtrable acidity increased to a peak at colour stages 3 and 2 respectively and this declined.



Phenolic compound

Phenolics are responsible for the astringency of bananas before ripening, and also for certain browning reactions. They are localized mainly in the latex vessels of the pulp and peel. Loss of astringency during ripening is due to polymerization of the phenolics.

Palmar (1971) stated that banana fruit tissues and particularly the peel are rich in phenolics, such as 3 4-

dihydroxyphenyl ethylamine and 3,4-dihydroxyphenylalanine. These compounds, when oxidized by the enzyme poly phenoloxidase are responsible for the rapid browning of banana tissue.

Jayaraman *et al.* (1987) identified two major fractions of polyphenoloxidase activity from banana and examined the rates of enzymic browning and polyphenoloxidase activity in a range of banana cultivars. Those cultivars which exhibited low browning rates had low polyphenoloxidase activity and a high ascorbic acid content.

Lizada *et al.* (1990) stated that bananas and plantains can contain high levels of phenolic compounds, especially in the peel. Phenolics, such as tannins, are polymerized to insoluble compounds, resulting in a reduction of astringency in the ripe banana fruit.

Tannins are present in banana fruit tissue and particularly in the fruit peel. These compounds are generally defined as water soluble phenolics having molecular weights between 500 and 3000 and having special properties, such as the ability to precipitate alkaloids and proteins.

Tannins react with salivary proteins and glycoproteins, this ability of binding with protein has long been recognised as a major problem to be overcome when extracting active enzymes from banana tissue. Studies on the structure of banana tannins have been limited, however tannins of the proanthocyanidin (leucoanthocyanidins) type have been reported. These phenolic compounds have a distinctive reaction with acids to give anthocyanidins.

Excessive browning of phenolics in the latex vessels of the peel, promoted by temperature below 13°C, is

commercially important, causing the disorder called 'under peel discoloration'.

3. QUALITATIVE CHANGES

Colour

The most obv[illegible] during ripening in many fruits is their external colour. The pigments in the peel of bananas and plantains are chlorophylls, carotenoids and xanthophylls. The change in colour of ripening fruits is associated with the breakdown of chlorophylls, with carotenoid [illegible] remaining constant. Cavendish banana cultivars [illegible] they are ripened at [illegible] et al., 1987, Semple and Thompson, [illegible] banana which are ripe in every [illegible] in green stage this may be due [illegible].

Chlorophyll [illegible] in concentration of 12.13 mg [illegible] in banana plantains (Seymour et al., [illegible] fresh weight.

The pulp [illegible] bananas at the time of harvest [illegible] yellow in colour. As it ripens, [illegible] yellow in colour (Wainwright and [illegible].

Colour changes in banana during ripening are carried out by using the colour chart which is given by Stover and Simmonds (1987) and the time taken to reach 100 per cent ripening colour from the date of harvest was noted and it will be expressed in number of days.

stages of ripening

I - All green (hard green)

II - Green with a trace of yellow

III - More green than yellow

IV - More yellow than green

V - Yellow with a trace of green

VI - Fully yellow

VII - Fully yellow with brown speckles

The advanced stages of banana ripeness are characterised by the appearance of brown flecks (or) spots on the skin.

Colour of the fruit in different stages

Sl.No.	Variety	I	II	III	IV	V	VI	VII
1	Nendran	G	G	G	GY	GT	Y	Y
2	Palayankodan	G	G	G	GY	GT	Y	Y
3	Karpooravally	G	G	G	GY	GT	Y	Y
4	Monthan	G	G	G	GY	GT	Y	Y
5	Robusta	G	G	G	GY	GT	LG	LG
6	Red banana	MG	MG	MG	MG	MB	MB	MB
7	Kunnan	G	G	G	GY	GT	Y	Y
8	Njalipoovan	G	G	G	GY	GT	Y	Y
9	Kadali	G	G	G	GY	GT	Y	Y
10	Matti	G	G	G	GY	GT	Y	Y
11	Kanchikela	G	G	G	GY	GT	Y	Y

G - Green, MG - Maroonish green, GY - Greenish yellow

GT - Greenish tip, Y - Yellow, LG - Light green

Colour of the pulp in different stages

Sl. No.	Variety	I	II	III	IV	V	VI	VII
1	Nendran	OW	OW	OW	LY	PY	DY	DY
2	Palayankodan	OW	OW	OW	C	C	LY	LY
3	Karpooravally	OW	OW	OW	C	C	LY	LY
4	Monthan	OW	OW	OW	OW	OW	C	C
5	Robusta	OW	OW	OW	OW	OW	C	C
6	Red banana	PY	PY	PY	PY	LY	LY	LY
7	Kunnan	OW	OW	OW	OW	OW	C	C
8	Njalipoovan	OW	OW	OW	OW	C	C	C
9	Kadali	OW	OW	OW	OW	LY	LY	LY
10	Matti	OW	OW	OW	OW	LY	LY	LY
11	Kanchikel	OW	OW	OW	OW	C	C	C

OW - Off white, PY - [illegible], LY - Light yellow

C - Cream, DY - [illegible]

The rate of chlorophyll degradation in the banana follows an [illegible] temperature. At 30°C the rate is maximum [illegible], there is very little green colour [illegible] and very little. Chlorophyll breakdown [illegible] and there after.

Quantitative changes in carotenoids in the peel of ripening bananas from [illegible]

Carotenoid (µg per 10 g fresh weight)	Ripening stage			
	Green	Green yellow	Yellow green	Yellow
β-carotene	27.4	12.2	16.4	20.0
α-carotene	40.8	18.8	37.1	30.6
β-carotene-5,6-epoxide	-	-	-	1.7

Unknown mixture	-	-	-	1.6
α-cryptoxanthin	-	-	1.1	3.0
Cryptoxanthin	-	-	1.1	2.5
Cryptoxanthin-5,6-epoxide	-	-	-	1.5
Lutein	80.4	42.1	57.6	78.6
Isolutein 'a'	5.4	2.7	5.3	1.9
Isolutein 'b'	2.0	2.7	7.0	5.5
Antheraxanthin	2.8	1.4	2.5	2.9
Luteoxanthin	1.4	1.9	5.4	3.8
Violaxanthin 'a'	19.0	3.4	8.8	4.0
Violaxanthin 'b'	-	3.8	2.2	12.9
Neoxanthin	[illegible]	11.0	15.4	19.6
Total carotenoids	[illegible]	100.0	160.0	190.0

A number of [illegible] Plucel, 1982 have examined the [illegible] of banana peel and pulp. This [illegible] production in total carotenoid [illegible] during the early stages of ripening follow[illegible] at the yellow-green to yell[illegible].

The pe[illegible] of fresh weight [illegible] cent, β-carotene [illegible], but in the pulp contained [illegible] consisting

33% - α-carotene

28% - β-carotene

33% - lutein

An optical chlorophyll sensing system was developed to detect the chlorophyll content of banana peel as the fruit ripens. This method shows a high correlation to other peel colour analysis (spectral analysis, tristimulus colorimeter

analysis and visual colour matching) this optical chlorophyll sensing system has to following characteristics, rapid response, simple operation, non-destructive measurement and inexpensive (Meng et al., 1997).

Softening (firmness)

According to Peacock (1980) an early part of the ripening process is the softening of the fruit. This happens partly because of loss of water from the peel but primarily because of the changes in the chemistry of the cell walls.

Kojima et al. [illegible] on ripening there is a decrease in the viscosity and the elasticity of pulp. The major physical factor associated with pulp softening, was related to the sequential [illegible] of starch, pectic and hemicelluloses in [illegible]

Softening [illegible] breakdown of starch and other non-p[illegible] in 16-pulp, there by reducing the [illegible].

According [illegible] has given the three reason for softening [illegible]

(1) breakdown [illegible],

(2) breakdown [illegible] due to the solublization of pectic subst[illegible] followed by breakdown of cellulose

(3) the movement of water from the peel of the banana to its pulp during ripening. This process affect the turgidity of the skin. which would be enhanced by transpirational losses.

Texture serves as an important determinant of quality in harvested fruits. The textural changes in fruits occurs largely as a result of the enzyme mediated hydrolysis of cell wall.

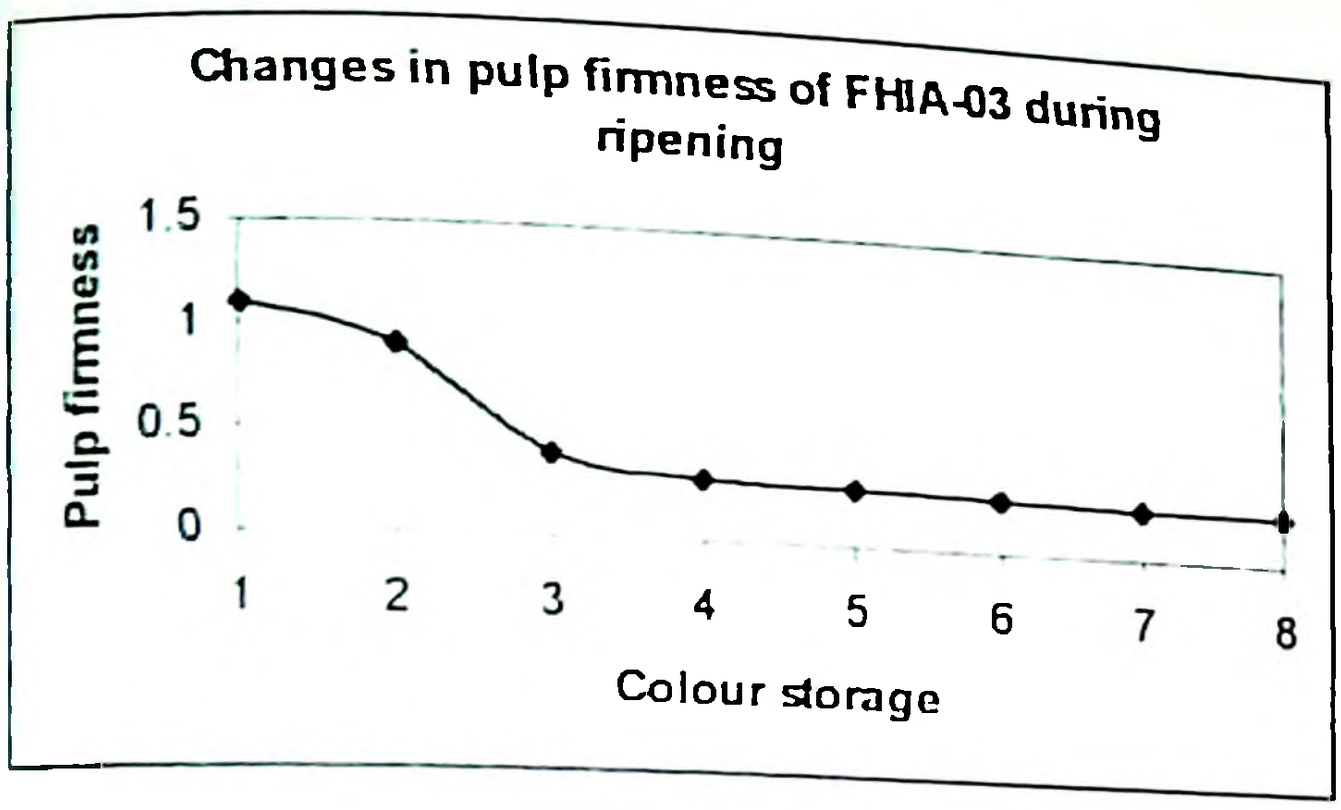
In between the primary and adjoining cell of the cell wall containing the layer known as the middle lamella, this layer is particularly rich in pectic polysaccharides, during fruit softening, this particular layer must be affected. This is mainly due to involving of enzymes like Exo-D-Galacturonanases and Endo-D-galacturonanases.

This firmness of the fruit and pulp was measured by penetrometer method using (Model FT 001 (0-5 kg) and Model FT 001 (5-13 kg) readings were noted from the pressure gauge as kg per sq.cm.

Firmness of fruit [illegible] (Thangadurai, 2000)

Sl.No.	Variety	Mean
1	Nendran	4.06
2	Palayankodan	1.43
3	Karpooravally	1.96
4	Monthan	1.96
5	Robusta	1.90
6	Red banana	2.40
7	Kunnan	1.76
8	Njalipoovan	1.83
9	Kadali	2.13
10	Matti	2.26
11	Kanchikela	2.73

Study shows, the firmness of the fruit varied from 1.43 to 4.06 kg cm . The highest value was recorded in Nendran and lowest in Palayankodan. The varieties like Karpooravally, Monthan, Robusta, Kunnan, Njalipoovan and Matti shows there were no significant differences.



Under normal storage conditions, cooking bananas shows a progressive [illegible] pulp firmness over the cause of ripening. Pulp firmness decreased from an initial value of about 1.[illegible] kg t at colour stage 1 to nearly 0.3 kg t at colour stage [illegible]. Most of the decrease occurred in about 0.12 kg t at colour stage [illegible]. Most of the decrease in pulp firmness during ripening is associated with the solubilisation of pectic substances in the cell wall and middle lamella.

Volatiles

A wide [illegible] compounds emanate from ripe bananas, [illegible] alcohols, ketones, aldenydes and [illegible] account for about 70% of the [illegible] and acetates and butyrates predominate within this [illegible].

Uritani et al. (1) examined to odour compounds of the peel of mature green fruit of cvs Cavendish (AAA), Latundan (AAB), Lakatan (AA) and Saba (BBB). Their interest was in the biochemistry of the compounds. Produced immediately after the fruits is peels. They measured the activity of lipoxygnase and hydroperoxidelyase in the peel of mature green and mature yellow fruit and examined the volatiles using gas chromato graphy. The activity of

lipoxygenase, and as a consequence the amount of C_6 and C_9 volatiles produced, decreased substantially as the fruit ripened.

The three main pathways for biosynthesis of volatiles have been established

(1) Conversion of amino acids such as leucine and valine into acids and alcohols.

(2) Production of acids, alcohols, esters and ketones via fatty acid metabolism.

(3) The oxidative cleavage of linoleic and linoleinic acids to C, C and C aldehydes and oxo-acids.

Palatability

This is mainly determined by sugar:acid blend and other compound which are present in the fruit. That will impart the taste, flavour and sweetness.

Palatability depend upon the harvest maturity. It is recommended before attaining the sufficient level of physiological maturity. Then it subjected to ripening, some changes can be takes put it is (colour etc.) not appreciable.

The sweetness is measured by Hedonic scoring scale (Dadzie, [illegible])

Scale	Texture	[illegible]	[illegible]	Sweetness	Overall acceptbility
5	Very firm	[illegible]	Excellent	Too sweet	Excellent
4	Firm	Very acceptable	Like very much	Very sweet	Very good
3	Soft	Good	Good	Sweet	Good
2	Very soft	Fair	Fair	Slightly sweet	Fair
1	Too soft	Poor	Poor	Unsweet	Poor

Hybrid/cultivar cultivar	Texture	Taste	Flavour	Sweetness	Overall acceptability
FHIA-01	3.70	2.28	2.25	1.71	2.08
FHIA-02	3.19	2.44	2.44	1.94	2.43
Grand Naine	3.74	3.54	3.50	2.83	3.51
Williams	3.84	3.64	3.56	2.87	3.57

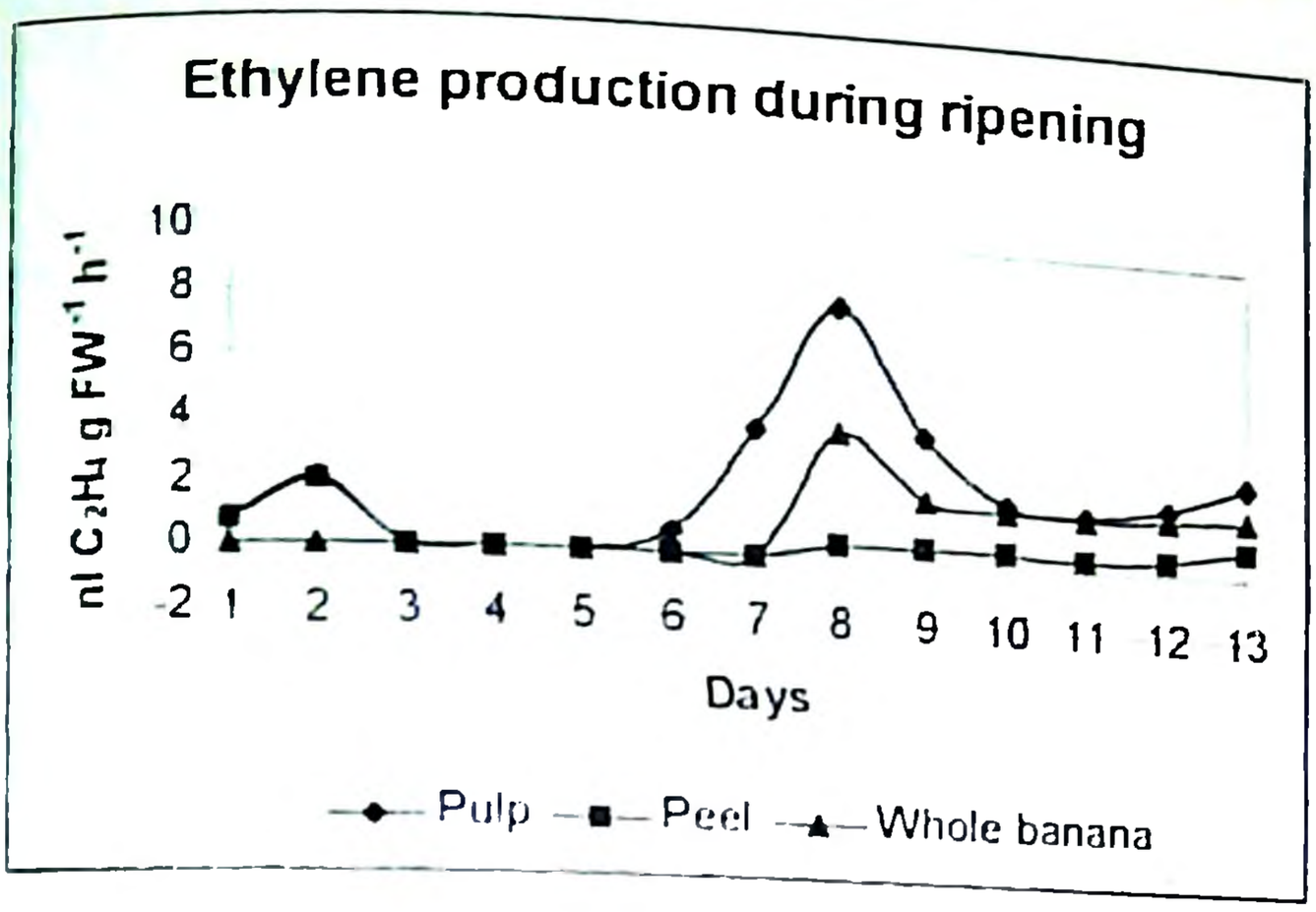
This tables shows that the over all acceptablity is very high in varieties grand naine and williams.because of thesed from good to very good.bud FHIA-01 & FHIA -02 came fair to good.

4. ETHYLENE BIOSYNTHESIS

Ripening [illegible] such as the banana shows a rapid rise in [illegible] autocatalytic ethylene production. In [illegible], ethylene is produced from methionine via [illegible] S-adenosyl methionine (SAM) and 1-aminocyclopropane-1-carboxylic acid (ACC) Yang, 1981. ACC synthase and [illegible] enzyme (EFE) are the key enzymes in the [illegible] ethylene biosynthesis.

In climacteric [illegible], regulation of ethylene biosynthesis occurs [illegible] both in ACC availability and on the capacity [illegible] to convert ACC to ethylene (Yang, 1987). The level of ACC can be regulated by its rate of synthesis and conversion to ethylene as well by its conjugation to Malonyl-ACC (MACC). On the other hand, ethylene is capable of regulatory the activity of EFE. ACC synthase and Malonyl-ACC transferase.

Ethylene production during ripening



This [illegible] the evolution of ethylene production [illegible] separated peel and pulp during experiment.

In [illegible] production is almost undetectable [illegible] phase. An increase occurs [illegible] same time as the respiratory [illegible] attained [illegible] the respiratory dimacteric [illegible] then increases to reach fairly constant [illegible] ethylene production in peel and [illegible] peak due to the stress caused by [illegible]. The peak is slightly higher in pulp, [illegible] from the effect of cutting in about 24 h, the peak of ethylene production related to the climacteric is shown only by the pulp, and it is higher (8 nl g F w h) then in whole fruit. The peel produces small amounts of ethylene, coinciding with tissue senescence.

5. RESPIRATION

The banana is a climacteric fruit, i.e. the ripening process is associated with a burst of respiration. Which reaches a peak after some three or four days and then declines but remains high for the Cavendish cultivars (AAA) at 20°C the respiration rate at the peak is from three to five times the preclimatric level of 10 to 20 mg Co kg⁻ h⁻' (Peacock and Blake, 1970). Similar rates occurs in cv. Gros Michel (AAA) (Gane, 1936) in some cultivars in south east Asia, however, rates are much higher at 140 mg Co kg⁻ h⁻ for cv. Latundan AAB and almost 200 mg Co kg⁻ h⁻ for cvs Senorita and Pisang Phil AA .

A few hours [illegible] the respiratory climacteric begins there is an increase in [illegible] from 0.5 ml kg⁻ h⁻ in pre[illegible] [illegible] (Mc Murchie [illegible] occurs when [illegible] maximal rapidly.

The [illegible] respirat[illegible]

Respir[illegible]

Co , and [illegible]

It [illegible]

$C_6H_{12}O_6$ + [illegible]

glucose oxyg[illegible]

6. ENZYMATIC REGULATION

The change in enzyme activity in ripening bananas to account for the increased respiratory activity during climacteric and the changes in the level of glycolylic and fruit softening enzymes has been investigated.

Ascorbic acid oxidase activity in bananas stored at 13°C increased until they turned yellow and then remained

steady for the rest of the ripening period (Patil and Magar, 1975).

In varieties Basrai, Harichal, Lalkel, Rajabale and Safed Velchi, the acid phosphatase activity in super natant fraction^{-1} increased 2 to 2.5 fold in most varieties and the activity in fraction-II increased 3 to 6 fold as the fruits ripened (Patil and Magar, 1976).

The relative activities of hydrolytic and oxidative enzymes viz. α-amylase, starch phosphorylase, acid phosphorylase, catalase and peroxidase increased in banana varieties Pachbale, Rajabale and Rajabale during ripening. An upsurge (rise) in the activities of all the enzymes to a maximum of [illegible] times of the initial level was observed.

An increase in the activity of respiratory enzymes peroxidase with [illegible] ethylene production and conversion of [illegible] was observed during ripening (Patil and [illegible], [illegible]. Nabusa and Unnikrishnan (1989) reported [illegible] in α-amylase and invertase activity at the [illegible] in total sugars.

The [illegible] PFK and PEPC activity were studied (Satyan [illegible], 1990b) in ripening Dwarf Cavendish [illegible]. PEPC activity remained unchanged during ripening. [illegible] of PFK activity was noticed throughout the period. PFK activity was high at climateric than at pre-climacteric stage.

Electrophoresis studies have indicated two forms of PFK at the two stages. Iyer *et al.* (1989) identified three multiple forms of PFK in ripening banana and named there as oligomeric, dimeric and monomeric. A corrulation between the ripening process and conversion of oligomeric PFK to

he more active monomeric form was observed. Over 90 per cent of the PFK enzyme existed in monomeric form in the fully ripend fruit.

Selvaraj and Rajivkumar (1987-89) reported that the activity of glycolytic regulatory enzyme, Pyruvatekinase (PK) increased from mature stage to 2 days after harvest and declined at peel colour turning stage in Rasthali variety.

Hexokinase and PFK activity were extreamly low in enzyme preparations from acetone powder of the fruit pulp. The activity of [illegible] gluconeogenic pathway regulatory enzymes, G6-pase which was maximum at harvest maturity, declined during ripening. [illegible] activity increased during ripening. ME and [illegible] hydroxylase enzymes activity increased [illegible] days after harvest. The activity [illegible] turning stage followed by an increase [illegible].

Banana [illegible] registered an increased cellulase [illegible] ripening, where as in peel, maximum [illegible] at mature stage. Both peel and pulp [illegible] PME activity from harvest [illegible] turning stage which decreased during ripening. PG activity, both in peel and pulp, increased during ripening.

Changes in PPO activity was studied in pulp tissues of three varieties of banana viz., Dwarf Cavendish, Poovan and Rasthali. Gel electrophoresis of partially purified PPO and buffer soluble proteins revealed varietal differences in changes in PPO iso-enzymes and protein pattern during ripening with synthesis of new iso-enzymes and proteins in pre-climacteric and climatric tissues and their degradation in post-dimacteric tissues (Jayaraman and Ramanuja, 1987).

declined PPO activity in pulp and increased activity in eel tissues during ripening was observed in Rasthali anana.

. CONCLUSION

Understanding the basic concept of ripening is a very mportant factor that will lead to the farmer as well as he industrialists to take the precausionary measures uring storage as well as th trasportation.

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9. DISCUSSION

1) What is the difference between the self life and green life?

Shelf life: It is a period in between the initiation of ripening and end of saleable life.

Green life: Green lie is the time the harvested fruits takes to ripen in an ethylene free, humidified air steam at a specific temperature. It is the preclimacteric stage of fruit development after harvest a normal range of green life at 20°C is 5-30 days.

2) What are all the deliterious changes in relation to the producer and consumer

In relation to the producer the factors changes like weight loss is considered as a deleterious changes because it affects the quality of the product. Whereas in relation to the consumer the factors such as over colour changes like blackish, over softness, high acidity, less sugar content are considered as a deleterious changes apart from the normal changes during ripening.

3) Do you know how the autocatalysis will be induced?

In banana, [illegible] seems to indicate that the increase in EFE activity is the key factor regulating the start of autocatalytic ethylene production. The initial increase in ethylene would induce the increase in activity of the ACC synthase, thus increasing the ACC content and at the same time, EFE activity, producing autocatalysis.

4) Is there any relationship with gene expression in banana ripening?

Yes.

What are all the differential gene expression in relation to ripening of banana?

During banana fruit ripening ethylene production triggers a developmental cascade that is accompanied by a massive conversion of starch to sugars, an associated burst of respiratory, activity and an increase in protein synthesis. Differential screening of cDNA libraries representing banana pulp of ripening stages 1 and 3 has led to the isolation of differentially expressed mRNAs. Identification of these transcripts by partial sequence analysis indicates that two of the mRNAs encode proteins thought to be associated with pathogenesis, [illegible] stress response in plants. Their relative abundance in the pulp and tissue specific distribution in greenhouse-grown banana plants were determined by Northern-blot analysis. The relative abundance of transcripts encoding starch synthase, granule-bound starch synthase, chitinase, lectin, and a type-2 metallothionein and a putative senescence related protein increased early in ripening.

10. ABSTRACT

Banana (*Musa spp*) is a commercially important tropical fruit crop. India contributes 31 per cent of the world production with an annual production of 11 million tonnes. Banana being a climacteric fruit, its postharvest behaviour is crucial for the efficient marketing. Ripening is a process in which a physiologically mature but often inedible plant part is transformed to an attractive palatable fruit with characteristic flavour.

Angularity of finger, number of days, caliper grade and considered as indices of maturity of fruit in banana. Seven distinct stages have been described during ripening in banana. During ripening there is a decrease in fresh weight ranging between 4. [illegible] 14.4 per cent. The pulp to peel ratio changes from 1.[illegible] to 9.33 in most of the indigenous varieties.

Quantitative changes during ripening results from the change in [illegible]. Moisture content increases in the pulp [illegible], while it decreases in peel. Starch content decreases from [illegible] per cent in raw fruit to less than [illegible] per cent in the ripe fruit. During ripening, acids, phenolic substances and proteins show a decreasing trend.

The quantitative changes during ripening account for the edible quality of fruits. During the process of ripening, the peel colour changes due to progressive degradation of chlorophyll pigments and expression of yellow colour contributed by carotenoids. Pulp colour also changes from white or pale yellow to yellow.

Softening of tissues during ripening occurs due to break down of pectic substances and cellulose. Enzymes like

Polygalacturonases (PG), Pectin methyl esterases (PME) and cellulases are involved. Break down of starch into soluble sugar is one of the major changes associated with ripening of banana. The sugar-acid ratio which gives an index of palatability changes from 40 to 180. More than 350 volatile compounds are believed to contribute the characteristic aroma of banana, the major one being amyl esters.

The quantitative and qualitative changes associated with the ripening of banana is influenced by various preharvest and postharvest factors like the stage to harvest, ambient temperature, relative humidity, oxygen and carbondioxide concentrations.