COMPARATIVE STUDY OF SUN-DRYING AND CABINET-DRYING ON QUALITY AND DURABILITY OF SPINACH [Spinacia oleracea] AND GRAM (Cicer arietinum) LEAVES

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

[AGRICULTURAL UNIVERSITY]

RAHURI (DIST. AHMEDNAGAR)

(MAHARASHTRA STATE)

in partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

in

HORTICULTURE

By

NIRMALCHANDRA KESHAV DESHMUKH

B. Sc. (Agri.) First Class

DEPARTMENT OF HORTICULTURE

Post Graduate School, Rahuri

SEPTEMBER, 1979

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C E R T I F I C A T E

This is to certify that the thesis entitled "COMPARATIVE STUDY OF SUN-DRYING AND CABINET-DRYING ON QUALITY AND DURABILITY OF SPINACH (*Spinacia oleracea*) and GRAM (*Cicer arietinum*) LEAVES" submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmednagar, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE embodies the results of a piece of bona fide research work carried out by Mr. NIRMALCHANDRA KESHAV DESHMUKH under my guidance and supervision and no part of thesis has been submitted for any other degree or publication.

Mr. Nirmalchandra Keshav Deshmukh has completed necessary course work for the degree and passed the preliminary examination.

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Date : 13.9.1979

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C E R T I F I C A T E

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Rahuri,

Date : 14/9/79

(G. K. Zende)

A C K N O W L E D G E M E N T

The exploration of an opportunity claims versatile guidance which I was fortunate enough to gain from Dr.D.A. Rane, M.Sc.(Agri.), Ph.D. (Pennsylvania, U.S.A.), Professor of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The present thesis is a issue comming out of unlimited and relentless efforts made by him while directing me to carry out the research and writing the manuscript.

No words are enough to express my sincere sense of gratitude to Dr.A.V. Patil, Head, Department of Horticulture of the aforesaid institute, for his valuable help and useful suggestions in prosecuting this study.

I express my grateful thanks to Dr.B.B. Desai, Associate Professor, Department of Soil Science and Agriculture Chemistry of abovesaid institute for his constructive suggestions in conducting this research. I extend my sincere thanks to Prof. A.K. Thorat, Project Officer, Food Technology, for his timely assistance.

It gives me pleasure to acknowledge my indebtedness to Prof. K.N. Kavhal, Dr.K.U. Sanghavi and Dr.U.T. Desai, Dept. of Horticulture for their kind and willing co-operation. Thanks are also due to Shri Kaulgud (AFS Horticulture) for his valuable co-operation during the period of investigation.

I will be failing in my duties if I do not mention my sincere thanks to my upright and adherent friends R.R. Shinde, V.P. Kalbhor and A.J. Shinde for their kind co-operation and fruit bearing discussions. Thanks are also to Shinde for typing the thesis neatly and accurately.

I wish to express my cordial feeling of love to my parents, without whose inspiration the study would not have seen the light of the day.

Rahuri,

Date : 14th Sep. 1979.

Nirmalchandra Deshmukh

C O N T E N T

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CHAPTER I

I N T R O D U C T I O N

CHAPTER I

I N T R O D U C T I O N

Since antiquity man has been evolving methods of conserving food in various ways. Preservation of food in one form or other has been practised since pre-historic time but the scientific approach for it's development is about a century old. Numerous methods have been employed in preserving foods and drying is one of the earliest methods to be adopted for this purpose.

The first artificial drying (dehydration) of vegetables was done in 18th century (Prescott and Procter, 1937). In recent years food preservation has become a major industry all over the world. People demand greater variety of food and often they use foods, from another country, which have certain specific taste and are exotic. Due to increasing trend of vegetables production and as a result of improved varieties and facilities for growing vegetables in areas where they were not already grown, a glut in market is created during peak production season and spoilage occurs. The impact of seasonal glut and quantum of loss due to spoilage can be minimised if the vegetables are carefully handled, transported, processed, packaged and stored.

Food is an important item of the total expenditure in the world and therefore the cost of food plays a vital role in the cost of living of any country. So the economics of production, varying climatic conditions, seasonal availability, consumer's demand, need for variety and labour cost necessitate preservation of vegetables and fruits.

Fruits and vegetables are the most important food of mankind as they are indispensable for the maintenance of health. They are the major suppliers of vitamins, minerals, sugar etc. They can be stored by different methods as under refrigerated condition or in a frozen state. They can also be dehydrated or concentrated in a number of ways and consumed latter on. Hence the ultimate aim of feeding more population on limited land resources lies in the study of such types of food storage and preservation. Drying of vegetables has, therefore, attained paramount importance in the whole field of food preservation.

Dehydration of fruits and vegetables is beginning to emerge as a major method of food preservation. Dehydration made it possible to provide a healthy and variety diet to man. Amongst all the possible food preservation techniques, the methods of dehydration specially commended itself to military planners during the two world wars because of its space and weight saving possibilities. Therefore, rapid expansion of dehydrated food production facilities was undertaken by all the warring nations.

India is an ideal country for the growth of the dehydration industry. Dehydration offers excellent advantage over other methods of preservation in India. Prevailing high temperatures in this country lead to quick spoilage and there is need for rapid removal of water from food. Dehydration is the cheapest method of food preservation when other methods like cooling and refrigeration are used. Canning of food is an alternative for dehydration but use of valuable tin plates and steel plates, difficulty in sterilising large cans, high cost of processing and transportation call for dehydration to play a key role in the processing of vegetables in India.

Ten million tonnes of fruits and vegetables perish every year (Nanda, 1978). In India where there is hunger problem, it is not adviseable to waste such a large quantity of food. It is a challenge for Indian food preservers. By adopting dehydration technique, we can save a large amount of food from spoilage. In a country like India which has a wide and varied production of 32,000,000 tonnes of fruits and vegetables, only 55,000 tonnes are preserved. Out of that about 15,000 tonnes are exported and 40,000 tonnes are utilised in the country (Saxena, 1977).

There are three distinct segments of the domestic demand (i) Army purchase organisation (APO) and canteen store department (CSD), (ii) Hotels and Restaurants and (iii) Household consumers. The demand estimate shows that purchase of APO and CSD account for 8,000 to 10,000 tonnes, hotels and restaurants, 7000 to 10,000 tonnes and purchases of household consumers are about 20,000 to 25,000 tonnes. Statistically this would mean that a country with a population of over 600 million consumers uses processed fruits and vegetables to the extent of only 25,000 tonnes annually and per capita consumption is only 40 grams. Increase in export was observed, during the first 11 months of financial year 1976-77 to be Rs.86.08 crores as against

Rs.42.70 crores during the corresponding period of previous year.

Gram is an important pulse crop and is widely grown in India. For better production, it is a practice with the growers to remove the tender tips of the growing stem to induce branching. This lasts only for a couple of weeks. The gram leaves as green and dry, is a popular vegetable of Maharashtra. As it is strictly season-bound crop and has a short season availability with a peculiar peak point of harvesting, it needs to be preserved for use in the off season.

Spinach is a world wide popular vegetable. It is nutritious and is rich in vitamins and minerals. It is also very popular amongst growers due to its short duration for production. But the leaves being succulent are highly perishable. Spoilage occurs very quickly and cannot as such be transported to distant markets and has to be consumed immediately after harvesting.

With a view to standardise blanching treatment and method of drying for preparation of good quality product, studies were undertaken in fruit and vegetable laboratory of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The drying of foods in order to preserve them during seasons of abundance for consumption during season of shortage is an ancient art; its origin is not recorded but many of its practices have been handed down even into the present day and in some cases they form the basis of modern food manufacturing processes.

Dry vegetables have come to occupy a peculiar role in the whole field of food dehydration. Drying in sun is the oldest and cheapest method of food preservation. Artificial drying is the superior method of drying. Because of its control over temperature, time, sanitation and microorganisms, one can obtain a good finished product from this method. Such type of foods have more monetary value due to improved quality and yield while the sun-drying has an advantage in low cost of production but the product is of inferior quality. Food preservation by both the methods i.e. drying and dehydration is very easy and cheap to store and transport. Various workers have tried different pre-and post-treatment methods in drying or dehydration. Work done in this respect is reviewed here.

2.1 Blanching :

Adam *et al.* (1942) observed that blanching inactivates the enzymes, reduces the microbial load and improves colour, flavour and texture of the product. Melnick *et al.* (1944) studied the influence of hot water (100°C) and steam blanching of green snap beans upon the enzymes, indophenol oxidase and peroxidase. Hot water blanching of beans was more effective in destroying the natural enzymes, a three minutes exposure being almost completely effective in this respect. Five minutes steam blanching was necessary for complete inactivation of enzyme in green snap beans. They also found that there were much more losses of soluble nutrients during water blanching while such losses were not significant during steam blanching.

Schmimmer (1944) concluded that heating denatures the enzymes in the product. The degree of enzyme inactivation indicates the effectiveness of blanching treatments. Peroxidase inactivation in vegetable was more rapid when the product was heated at higher temperature but the enzyme inactivation by high temperature for short time reverted more completely to the active form on cooling than the enzyme inactivated to the same extent by longer exposure at lower temperature. Holmquest (1954) proved that steam blanching increases the density of peas than the conventionally water blanched ones as a result of which there are less number of floaters in steam blanched sample than in water blanched ones.

Tandon and Virmani (1949) found that the vegetables retaining peroxidase activity even after blanching for longer time should be blanched till active peroxidase is destroyed. Willer and Pettit (1957) obtained satisfactory dehydrated green beans by blanching in steam for 4-6 minutes. Welser (1962) stated that the drying ratio is higher in unblanched product than in blanched one. The blanching causes increase in the rate of drying removing intercellular oxygen from tissue, thus causing soft texture and retaining carotene and ascorbic acid during storage. Teotia and Awasti (1968) found that 0.2% sulphiting treatment to jack fruit bulb during blanching helps in maintaining cooking quality and rehydration ratio is better than the control samples.

Lund et al. (1972) stated that in blanching of food, enzyme must be inactivated but textural changes and leaching losses must be minimised. For this he advocated quick blanching. In Individual Quick Blanching (IQB) steam is applied to individual piece; in this case mass average temperature quickly reaches enzyme inactivation range.

Blanching is an initial processing and is important method of fruit and vegetable preservation (Annon, 1974). The foods are blanched to inactivate the biological system which would otherwise degrade the flavour or colour and system which cause the loss of vitamins. Patil (1976) concluded that five minutes at 80°C temperature, three minutes at 90°C temperature and two minutes at boiling temperature of blanching solution enable to denature all enzymes present in fenugreek leaves, while Lund (1977) stated that blanching with 100°C for ten minutes inactivates the enzyme system for vegetables and removes tissue gases. Pasteurization usually at 100°C inactivates the vegetative cells of pathogenic and spoilage organisms.

Pruthi (1978) blanched paddy straw mushroom for dehydration and found that inactivation of peroxidase and catalase prior to dehydration of mushroom was essential. The optimum time of water blanching was three to four minutes and that of steam blanching four to five minutes to inactivate the enzyme system. However, water blanching was found to be somewhat better than steam blanching as the latter seemed to adversely affect the colour of the product.

2.2 Chlorophyll :

Chlorophyll is responsible for green colour in vegetables. This pigment is held close to the cell wall in well defined bodies called chloroplasts with some xanthophylls and carotenoids. The chlorophyll A and chlorophyll B occur in plant in the ratio of 3:1. For colour retention in dried and dehydrated vegetables chlorophyll retention is most important.

2.2.1 Effect of processing on chlorophyll :

Legautt *et al*. (1950) studied blanching of peas and observed that the conversion of chlorophyll to pheophytin involves loss of Mg^{++} from the chlorophyll molecule and is evidenced by loss of bright green colour of fresh pea processed progressively with increasing blanching time. The degradation of chlorophyll is more rapid at 212°F (100°C) than at 190°F (87.7°C). A loss of 2.5%of chlorophyll occured when blanched for 120 seconds at 190°F (87.7°C) while 8.5 per cent loss was observed in 120 seconds at 212°F (100°C) temperature.

According to Wagenknecht (1952), chlorophyll is known to be acted upon by at least three enzyme systems viz. alphahydroxy-acid-dehydrogenase, chlorophyllase and lipoxidase. The alphahydroxy-acid-dehydrogenase system in green plants oxidises glycolic acid and glycolic acid is known to cause the decolorisation of chlorophyll in the course of oxidation. The chlorophyll is decolorised through an oxidative reaction in which it is claimed that an organic peroxidase is produced.

Dutton et al. (1943) proved that chlorophyll is converted into pheophytin during blanching. In their study they observed that 26 per cent of chlorophyll was converted into pheophytin in spinach leaves. The conversion according to their study, depends upon the blanching duration.

Dietrich (1958) also observed that there is conversion of chlorophyll to pheophytin during processing. A new formula has been put forth by him in which the amount of chlorophyll which is converted to pheophytin can be calculated.

Van et al. (1964) conducted study with tender green variety of snap beans. They showed that low blanching temperatures were associated with a rapid conversion of chlorophyll to pheophytin, as very little pheophytin was formed in pods receiving no blanching treatment. According to Dietrich (1965), water blanching inactivates enzyme faster and degrades less chlorophyll than blanching with steam in Brusell's sprouts. Chlorophyll was more stable in water blanching than in steam blanching which resulted in soft dull green coloured product. As the duration of blanching increases the losses of chlorophyll also increase.

2.2.2 Retention of chlorophyll :

Blair and Ayres (1943) found that green vegetables such as spinach or cabbage which produce considerable volatile acid during the early part of cooking, produced olive green colour which changed to dull brown when cooked in a pot with a lid but a better colour was retained when the lid was removed as the volatile acid escaped.

In a study of colour changes in blanched and unblanched peas for five years Wagenknecht et al. (1950) found that blanching helps in preserving chlorophyll. The amount of chlorophyll destruction at the end of first year was roughly 2/3rd of that found at the end of 5th year. Bhatia et al.(1963) treated the peas with sodium bicarbonate, magnesium oxide, sodium hexameta phosphate, sodium carbonate and potasium metabisulphite, for maintaining the green colour of peas. The pH of blanching solution was 7. The peas dipped in 2.0% sodium carbonate solution at room temperature for 30 minutes, washed in water and blanched in boiling water retained bright green colour. Blanching for 3-4 minutes in boiling water containing 0.1% sodium bicarbonate + 0.1% magnesium oxide + 0.4% potasium metabisulphite resulted in more retention of bright green colour in the dried product.

According to Gupte and Francis (1964) spinach processed by high temperature short time (HTST) method retained more chlorophyll and beta carotene. Spinach puree adjusted to pH 8.5 with magnesium carbonate and processed at 149°C in a glass thermal death tube (TDT) retained approximately 24% chlorophyll after six months storage at room temperature, whereas, similar samples processed at normal pH i.e. 7 in TDT tube at 250°F (121°C) retained only 6.0% chlorophyll after six months storage. The most effective compound used for pH adjustment was magnesium carbonate. Jafer et al. (1966) treated the okra with NaCl solution of 1.0%, 2.0% and 3.0%. The data showed that low temperature long time (LTLT) method i.e. 135°C (57.2°C) temperature for 15 minutes combined with the use of 3.0% salt as a covering agent helped in better retention of green colour i.e. retention of chlorophyll.

Desrosier (1970) reported that the retention of chlorophyll is directly related to the retention of magnesium in the pigment molecules under moist heating condition. The chlorophyll gets converted to pheophytin by losing some of its magnesium. Ramnathan and Bhatia (1970) found that initial pre-soaking in sodium carbonate solution resulted in brown product. Blanching in hot water produced product of faded green colour. But the blanching in boiling water containing 0.4 per cent potassium metabisulphite + 0.025 to 0.05 per cent sodium bicarbonate + 0.1 per cent magnesium oxide retained more green colour.

Sistenek et al. (1970) concluded that blanching treatment helps in colour retention of summer squash. Colour and ascorbic acid were lost very rapidly in unblanched squash puree. Kaur (1972) found that blanching of green leafy vegetables in two per cent sodium bicarbonate solution at 175°F for six minutes helped considerably in retention of green colour in the processed product.

Patil (1976) working with fenugreek found that blanching at boiling temperature with 0.5% KMS, 0.1% MgO and 0.1% $NaHCO_3$ retained maximum amount of chlorophyll while blanching at 80°C without chemicals lost most of it during storage. Contrary to this Daund (1977) stated that there is no significant effect of blanching on colour retention of canned beans.

2.3 Beta carotene :

Carotenoids are a group of yellow, orange and red fat soluble pigments in green leaves. The carotene is the mixture of three isomers, alpha, beta and gama carotenes. Beta carotene is widely distributed in leafy vegetables and mainly it is the precursor of vitamin A. The carotenoids are insoluble in water but are soluble in lipids. They undergo oxidation when exposed to air (Mayer, 1960) during processing of fruits and vegetables.

De (1936) concluded that both vitamin A and carotene are stable at normal cooking temperature. He has also reported that there was an increase in carotene content by 1.6% in green spinach leaves when cooked for 30 minutes in tap water. Booher et al. (1941) found more carotene in cooked product than in fresh one when analysed by both biological and chemical methods.

According to Gleim and Tressler (1944) the range of carotene in spinach varied from 3.79 to 4.64 mg/100 g on fresh weight basis and 62.113 to 69.543 mg/100 g on dry weight basis. When spinach weighing 600 g was cooked for eight minutes, 100% carotene was retained in the vegetable and there was no carotene leaching in cooking water. Morgan (1944) reported that the carotene was lost to the extent of 27 and 26 per cent during the dehydration of unblanched spinach and mustard green respectively.

Patil (1976) found HTST method to be the best method for retention of carotene in fenugreek leaves. Boiling temperature with 0.5% KMS + 0.1% MgO + 0.1% $NaHCO_3$ preserved most of the carotene in blanched samples of fenugreek leaves.

Feinberg (1973) observed that carrots packed in air after having blanched, sulphited and dried lost much of their carotene in a few months and developed off flavour. In case of unblanched ones the losses were as high as 93 per cent. The losses were 81.9 per cent in blanched and 77.2 per cent in blanched and sulphited carrots.

2.4 Ascorbic acid :

Ascorbic acid is very difficult to preserve during blanching and dehydration due to its oxidative nature. Being heat sensitive and water soluble, greater losses occur during blanching. Most of the leafy vegetables are rich sources of vitamin C (ascorbic acid).

2.4.1 Effect of processing on ascorbic acid :

Cruess (1943) stated that the loss of vitamin C in most of the dehydrated vegetables without blanching was severe and might amount to 100 per cent within a few weeks of storage. Blanching before dehydration retards the loss. He further observed that when the vegetables were slightly sulphured with sulphur dioxide or moistioned with bisulphite, they retained more vitamin C during storage.

Morgan (1944) found small differences between steam and water blanching of mustard green and spinach. During dehydration the unblanched mustard green and spinach lost their ascorbic acid to the extent of 75 to 80 per cent respectively as compared to 52 to 70 per cent losses in blanched produce. Stevens (1943) found that the losses of ascorbic acid during blanching varied with the product processed. Sweet potatoes, rutabagas and carrots lost about 10 to 20 per cent while it was 60 per cent in case of peas and white potatoes.

According to Gleim and Tressler (1944) the range of ascorbic acid in spinach varied from 42.9 to 44.1 mg/100 g, on dry weight basis. When 600 g of spinach was cooked for eight minutes the retention of ascorbic acid was 62 per cent in spinach and 19 per cent in cooking water. Russell et al. (1943) found that an addition of NaCl to blanching water materially reduced the rate of ascorbic acid losses and further showed that there was no loss of carotene when cabbage was scalded in sulphite solution.

Ireson and Eheart (1944) reported that when 240 g cabbage was cooked in 1200 ml of water in open pan for eight minutes 60.11 mg/100 g ascorbic acid was left in cooked cabbage as against 172.0 mg/100 g in raw cabbage and 41.84 mg/100 g of ascorbic acid was found in cooking water. They further reported that when 194 g cabbage was cooked in only 40 ml of water for nine minutes in tightly covered pan, the amount of ascorbic acid retained was 93.59 mg/100 g.

Eheart *et al*. (1945) studied blanching with and without chemical additatives and found that beans blanched with chemicals were higher in ascorbic acid content than unblanched ones. Lee *et al*. (1945) concluded that high temperature blanching helps in retaining ascorbic acid. The peas blanched for 60 seconds in rapidly boiling water lost 10 to 19 per cent of its ascorbic acid as against 30 per cent loss during commercial processing.

Janet (1945) proved that snap beans blanched by hot water method lost approximately 15 per cent of their ascorbic acid content while the steam blanching caused about 11 per cent loss. In cauliflower the hot water blanching lost about 19 per cent and steam blanching about 18 per cent of ascorbic acid. Noble *et al*. (1948) from their study of different methods of cooking spinach and other vegetables, recommended pressure saucepan for blanching which retained 78 per cent vitamin C in the cooked sample and 15 per cent in cooking water, as against 44 per cent in sample and 39 per cent in cooking water when blanched by open kettle method.

Rossoff and Cruess (1949) found that ascorbic acid oxidation affects the quality directly by destroying ascorbic acid thus reducing the nutritive value of vegetables. Heberlen *et al*. (1950) found that high temperature short time blanching of peas increased ascorbic acid retention. Gooding and Neil (1956) observed the losses of ascorbic acid during processing and dehydration. It was 28.5 per cent in case of water scalding and 22.7 per cent in steam scalding.

Malekar and Banerjee (1959) studied the retention of ascorbic acid during blanching and found that blanching the vegetables in sulphite solutions was the best method for ascorbic acid retention and better culinary quality. Blanching in 0.11 per cent sodium sulphite solution with or without sodium chloride and blanching with water alone had also beneficial effects. Gorden et al. (1964) found that raw cabbage contained 49.5 mg ascorbic acid/100 g on fresh weight basis. When cooked in water for 20 minutes the vitamin C content came down to 37.5 mg/100 g.

Apte and Patwa (1969) found that losses of ascorbic acid due to steaming were significantly higher than due to boiling water. On boiling for 45 minutes the retention of ascorbic acid was 31.5 mg/100 g while on steaming the retention was only 14.2 mg/100 g. They also stated that in raw radish tops vitamin C content varied from 42.0 to 63.1 mg/100 g with an average of 59.3 mg/100 g. After boiling the radish tops, retention of ascorbic acid was 37.4 to 56.2 mg/100 g with an average of 45.7 mg/100 g. On steaming, however, the vitamin C content was reduced to 13.2 to 28.8 mg/100 g with an average of 13.7 mg/100 g.

According to Singh (1972) blanching with 0.3 per cent KMS was good for avoiding browning of cabbage after dehydration and retention of ascorbic acid during subsequent storage. Ralls et al. (1973) observed that the loss of ascorbic acid during blanching was because it is water soluble and heat sensitive.

They found that spinach blanched by hot gas method retained 34 milligrams ascorbic acid per 100 grams as compared to 21 milligrams in case of the hot water blanching.

Labuza (1973) stated that ascorbic acid is destroyed rapidly by heat, light and oxidation. The losses vary from 10 to 50 per cent. The vegetable sulphited before drying increased its retention. Patil (1976) advocated blanching with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ at boiling temperature for retaining maximum amount of ascorbic acid during storage in fenugreek.

2.5 Changes in nutritive value during storage :

Thelma (1944) stated that the home drying method of beet caused 18 to 30 per cent loss of carotene on drying and the storage of 6 to 7 months increased the loss to more than 60 per cent. Sheart *et al.* (1945) stored the blanched and dehydrated samples of green beans in refrigerator and same set of samples at room temperature for six months. The best retention of vitamin C was found in cold storage while poor one at room temperature.

Morgan *et al.* (1945) stated that blanched samples of spinach lost less ascorbic acid than unblanched ones during storage. Very little quantity of thiamin and riboflavin was lost during storage of dehydrated spinach which was steam blanched. Janet *et al.* (1945) blanched snap beans and cauliflower by water and steam and stored in frozen condition. After nine months, snap beans and cauliflower had lost approximately

60 to 70 per cent of their original total ascorbic acid. The results were non-significant in the amount of ascorbic acid retained by hot water or by steam blanching methods.

Eheart (1946) concluded that the method of sulphuring made no difference in carotene retention during six months storage of dehydrated samples. While Dietrich <u>et al</u>. (1959) stated that HTST method of blanching resulted in more chlorophyll retention during storage than LTLT blanching.

Salem and Hegazi (1973) found that the sun-drying caused greater loss of carotenoid and vitamin C in apricot juice. The vegetables artificially dehydrated or sun-dried tend to loss their nutrient in the same order of magnitude as fruits. The rapid drying retains greater amount of ascorbic acid than does the slow drying and retains more vitamin C during storage.

Chapter Opener Page

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CHAPTER III

MATERIALS AND METHODS

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MATERIALS AND METHODS

During the present investigation the materials used and methods employed are enumerated below. The research work was carried out from February to June 1979, in the laboratory of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.1 Preparation of material :

The tender plant tops of gram as leafy vegetable was procured from the Horticultural farm. The spinach leaves were taken from the same farm when they had just attained their full maturity. They were smooth and leathery in texture. Both the vegetables were washed thoroughly in clean tap water to remove dirt, adhering soil and other impurities. Then the hard stem portion of gram and discoloured leaves of both vegetables were removed. The spinach leaves were chopped into pieces of 3 to 4 cm squares. Again both the vegetables were washed and used for further processing.

3.2 Blanching :

Blanching retains the chlorophyll and fixes the colour by inactivating the enzymes. For this purpose the washed material was placed in a clean muslin cloth and was tied loosely so as to facilitate easy entry of blanching solution upto the centre of tied material. It was dipped in a blanching solution for various timings as per treatments, where the ratio of blanching solution and blanching material was 4:1. The blanching material was then dipped immediately in clean tap water for 3-5 minutes to prevent further cooking of the material. The treatments were selected with a view to determine a suitable method to retain the food value with different chemicals with their various concentrations at different times of dipping and blanching temperatures.

3.3 Treatments :

Main treatments - a) sun-drying

b) cabinet-drying

Sub treatments - Blanching at various temperatures with and without chemicals like sodium chloride (NaCl), potassium metabisulphite (MKS), magnesium oxide (MgO) and sodium bicarbonate ($NaHCO_3$). The chemical concentrations were fixed on the basis of past work reported else where. The time, temperature and chemical concentrations for blanching as detailed below for spinach and gram leaves separately were fixed.

3.3.1 Spinach : Symbol

(1) 80°C ± 1°C temperature for five minutes (LTLT) (A_1)

i) Without chemical. (A_1B_0)

ii) With 2 per cent NaCl + 0.2 per cent KMS (A_1B_1)

iii) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ (A_1B_2)

(2) 90°C ± 1°C temperature for three minutes (MTMT)(A_2)

iv) Without chemical (A_2B_0)

v) With 2 per cent NaCl + 0.2 per cent KMS (A_2B_1)

vi) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ — (A_2B_2)

(3) Boiling temperature for two minutes (HTST) — (A_3)

vii) Without chemicals — (A_3B_0)

viii) With 2 per cent NaCl + 0.2 per cent KMS — (A_3B_1)

ix) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$. — (A_3B_2)

x) Absolute control in which the blanching was not done — (A_0)

3.3.2 Gram leaves : — Symbol

(1) 70°C ± 1°C temperature for five minutes (LTLT) — (A_1)

i) Without chemical — (A_1B_0)

ii) With 2 per cent NaCl + 0.2 per cent KMS — (A_1B_1)

iii) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ — (A_1B_2)

(2) 80°C ± 1°C temperature for three minutes (MTMT) — (A_2)

iv) Without chemical — (A_2B_0)

v) With 2 per cent NaCl + 0.2 per cent KMS — (A_2B_1)

vi) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ — (A_2B_2)

(3) 90°C ± 1°C temperature for two minutes (HTST) — (A_3)

vii) Without chemical — (A_3B_0)

viii) With 2 per cent NaCl + 0.2 per cent KMS — (A_3B_1)

ix) With 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ — (A_3B_2)

x) Absolute control in which blanching was not done — (A_0)

The treatment of blanching in boiling water for gram leaves was not followed as for spinach on the basis of preliminary trials, as the boiled leaves were pulpy.

The blanched material was immediately dipped in cold water for 3 minutes (Daound *et al.*, 1977) and was thoroughly drained and spread uniformly over the aluminium trays to a thickness of 3-5 cm. The trays were kept under sun and in cabinet drier for drying and dehydration respectively.

3.4 Sun-drying :

The material which was spread over the aluminium trays was placed under sun from 09.00 hours to 17.00 hours. The trays were covered with clean muslin cloth (Rane, 1978) so as to protect the samples from dust, flies etc. The samples were stored in room during night and were again placed under sunlight next day. During drying the material was stirred from time to time. It took on an average about 24 to 27 hours for complete drying.

3.5 Cabinet drying :

The blanched samples spread in the trays were kept in cabinet drier and the temperature during the drying period was maintained at 65°C ± 5°C. It took about 6 to 7 hours for complete drying.

After drying and dehydration the product was inspected thoroughly and discoloured pieces and foreign material if any were removed. The finished product was packed in polythene bags and stored at room temperature for 3 months for further study.

3.6 Observations :

3.6.1 Drying ratio :

It is a ratio of finished dry product to the prepared raw material before drying. It was worked out in both vegetables.

3.6.2 Rehydration ratio :

Rehydration ratio was calculated by putting 5 g of dehydrated or dried product in 100 ml of hot water at 75°C temperature in a beaker and kept till the product was just soft enough for consumption. At this stage the product was thoroughly drained and weighed and the rehydration ratio was computed. Rehydration ratio is the ratio of rehydrated product to dehydrated or dried product.

3.7 Chemical estimations :

3.7.1 Ascorbic acid :

Ascorbic acid gets destroyed during drying/dehydration and storage. In order to see the effect of blanching with or without chemicals on the retention of ascorbic acid, it was estimated in fresh as well as dried vegetables. Ascorbic acid (Vit-C) was estimated by 2-6 dichlorophenolindophenol dye method (A.O.A.C., 1975). The per cent of ascorbic acid was calculated as mg/100 g of the sample.

3.7.2 Beta carotene :

Beta carotene is an important ingradient of any leafy vegetable. Its retention in the dry product is essential. This was also estimated in the fresh as well as dry product.

The method of Beerh and Siddappa (1955) was adopted for estimating beta carotene. The concentration of carotene was calculated by comparing the value with standard carotene curve.

3.73 Total chlorophyll :

The chlorophyll was extracted by aqueous acetone method of Mackinney (1941) and the concentration of chlorophyll was determined by measuring the optical density of the solution using red filter at 663 and 645 mm wave length on colorimeter. The total chlorophyll was calculated from the equation given by Arnon (1949) :

$$\text{Total chlorophyll} = 20.2\, D_{645} + 8.02\, D_{663} \text{ mg/litre}$$

3.7.4 Culinary quality :

The culinary quality of the product was assessed by the taste by a panel of 5 judges and scores were given on the following aspects for the cooked product.

The marks allotted were :

	Marks
Colour	15
Flavour	15
Texture	15
Appearance	15
Taste	40
Total :	100

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CHAPTER IV

RESULTS AND DISCUSSION

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CHAPTER IV

RESULTS AND DISCUSSION

The results obtained in the various studies conducted with spinach and gram leaves on drying, dehydration, quality and durability are presented under appropriate headings and are discussed herewith.

4.1 Spinach :

The data on the effect of blanching chemical preservatives, time-temperature combination and drying method on the retention of chlorophyll, ascorbic acid, beta carotene and drying ratio after drying are presented in Table 1 and are graphically represented in Fig.1.

4.1.1 Effect on chlorophyll :

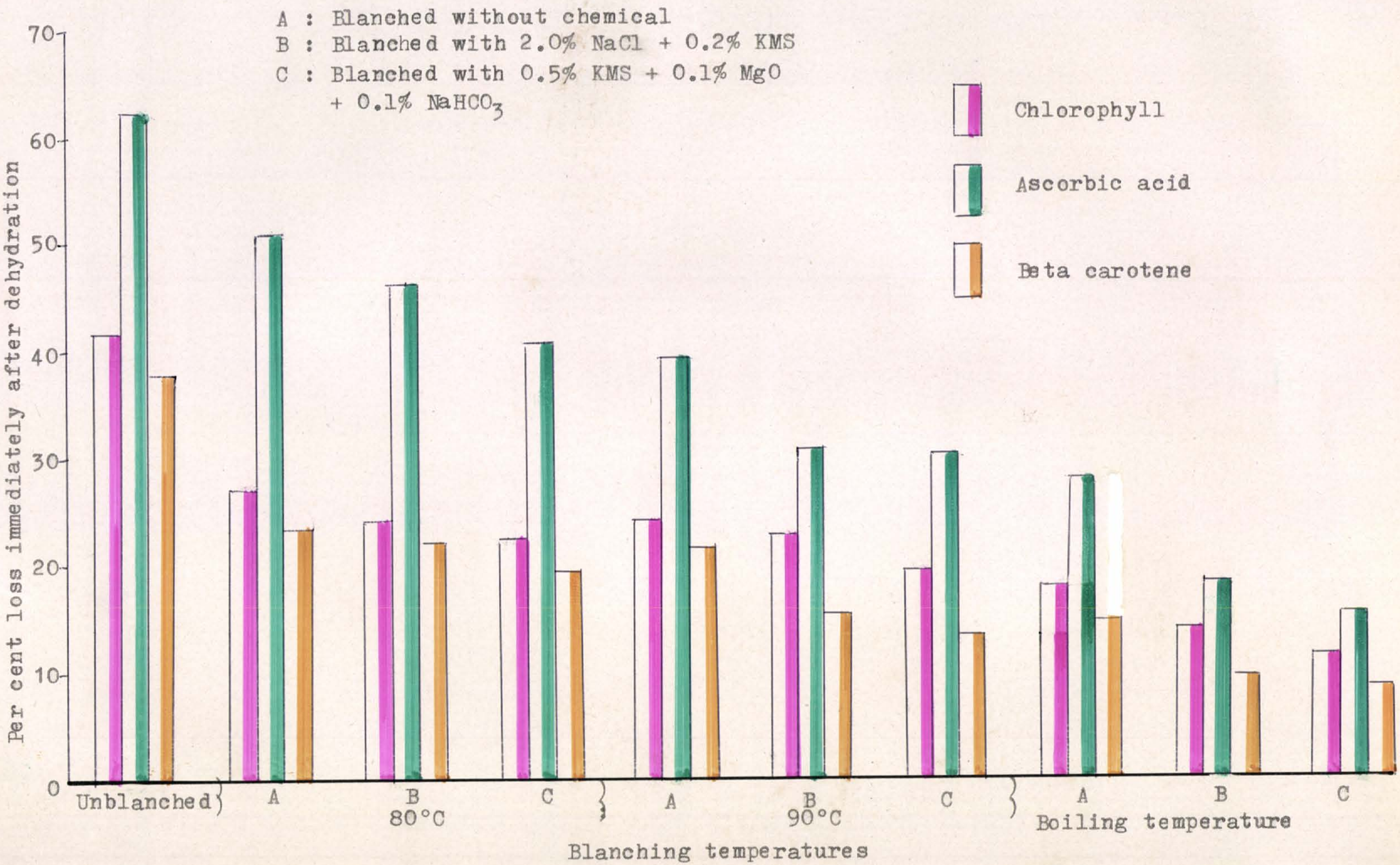
The data reveal that there was heavy loss of chlorophyll (53.74 per cent) in unblanched product as compared to blanched one with or without various chemicals at different time-temperature combinations. There was as much as 53.74 per cent loss in sun-dried control product and the loss was gradually reduced through different treatments and there was minimum loss (14.89 per cent) in the treatment which was blanched at boiling temperature for 2 minutes with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$.

Amongst the various chemicals used in blanching water, it was observed that 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ was better, followed by the other set of chemicals and no chemicals in that order. As regards the time-temperature combination, the high-temperature short-time (HTST) blanching was better than medium-temperature for medium d

Table 1 : Data on the effect of various treatments on spinach (Values calculated on dry weight basis).

Treatment symbol	Chlorophyll % loss		Ascorbic acid % loss		Beta carotene % loss		Drying ratio	
	Sun-drying	Cabinet-drying	Sun-drying	Cabinet-drying	Sun-drying	Cabinet-drying	Sun-drying	Cabinet-drying
A_0 (Control)	53.74	41.54	77.15	62.40	48.08	37.73	1:16.00	1:14.80
A_1B_0	38.51	27.19	65.71	50.89	32.52	23.41	1:15.00	1:14.10
A_1B_1	32.27	24.82	54.25	39.38	28.96	21.09	1:14.35	1:13.48
A_1B_2	28.01	17.45	43.79	27.86	21.59	14.76	1:14.00	1:13.11
A_2B_0	33.46	24.06	58.33	46.33	28.36	22.41	1:14.55	1:13.65
A_2B_1	30.17	22.67	45.80	30.80	21.12	15.06	1:13.80	1:12.84
A_2B_2	18.87	14.27	25.38	18.27	13.86	8.70	1:13.02	1:12.60
A_3B_0	30.55	22.86	47.89	40.73	26.60	19.32	1:13.92	1:13.02
A_3B_1	26.22	19.45	36.40	30.18	20.32	13.94	1:12.92	1:11.93
A_3B_2	14.89	11.59	20.90	15.63	11.02	8.55	1:12.07	1:11.06

Fig.1 : EFFECT OF BLANCHING WITH OR WITHOUT CHEMICALS ON CHLOROPHYLL, ASCORBIC ACID AND BETA CAROTENE IN CABINET-DRIED SPINACH LEAVES



low-temperature for long-time (LTLT) blanching with or without chemicals as there was gradual reduction in the loss of chlorophyll content with these combinations from LTLT through HTST.

Similar trend of reduction in chlorophyll loss was observed in cabinet-drying which was superior to sun-drying in each of the treatment combinations. The loss of chlorophyll was 41.54 per cent in cabinet dried control as against 53.74 per cent in sun-dried control. The minimum loss of chlorophyll was observed to be 11.59 per cent in cabinet-dried sample blanched at boiling temperature with KMS, MgO and $NaHCO_3$ combination, whereas, the loss was 14.89 per cent for the same treatment in sun-drying thus indicating the superiority of cabinet-drying over sun-drying method.

These results are pretty much in harmony with those published else where (Ammen, 1974). The foods are blanched to inactivate the biological system which would otherwise degrade the colour of the product. Dutton (1943) concluded that chlorophyll gets converted to pheophytin during blanching and the rate of conversion is dependent upon the duration of blanching. Van et al. (1964) found that low blanching temperature was associated with a rapid conversion of chlorophyll to pheophytin. Similar results were obtained by Gupte and Francis (1964). They found that spinach processed by HTST method retained more chlorophyll than that by LTLT method. Bhatia (1963) treated the peas with different chemical preservatives and found that blanching for 3-4 minutes at boiling temperature containing

0.1 per cent sodium bicarbonate + 0.1 per cent magnesium oxide + 0.4 per cent KMS resulted in more retention of chlorophyll in dried product.

4.1.2 Effect on ascorbic acid (Vitamin C):

The data presented in Table 1 clearly indicate that there was severe loss of ascorbic acid (77.15 per cent) in unblanched sun-dried control product as compared to blanched product with or without various chemicals at different time-temperature combinations. There was as much as 77.15 per cent loss in sun-dried control product and the loss was reduced by different treatments, and it was minimum viz. 20.90 per cent in the treatment which was blanched at boiling temperature for two minutes with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$.

As regards the superiority of chemicals used in blanching water, it was observed that 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ was better for retention of vitamin C. The next best alternative is the blanching with 2 per cent NaCl + 0.2 per cent KMS followed by the tap water blanching. As regards the time-temperature combination, the high-temperature short-time (HTST) blanching was better than the medium temperature medium time (MTMT) method and low-temperature long time (LTLT) blanching with or without chemicals as there was gradual reduction in the loss of vitamin C content with these combinations from LTLT through HTST methods of blanching.

The trend remained the same in reduction of ascorbic acid loss during cabinet-drying which was superior to sun-drying in each of the treatment combinations. The loss of ascorbic acid was 62.40 per cent in cabinet-dried control product as against 77.15 per cent in sun-dried control product. The minimum loss of 15.63 per cent of vitamin C was observed in a sample blanched with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ at boiling temperature for two minutes in cabinet-drying, whereas, the loss was 20.90 per cent for the same treatment in sun-drying. Thus, it is very clear that cabinet-drying is superior for retention of vitamin C to sun-drying method.

The main principle of food preservation is to inactivate the enzyme system and control the microorganisms causing decay. In the present study, by blanching the enzymes were made inactive. Further drying and dehydration resulted in the control over the microorganisms for want of sufficient moisture. By inactivating the enzyme system there was less loss of vitamins.

As the ascorbic acid is heat sensitive and oxidative in nature it is very difficult to preserve it during blanching and subsequent drying. From the results obtained in connection with ascorbic acid loss it is very clear that LTLT and MTMT methods of processing cause more losses than the HTST method. The reason may be that, the lengthy processing time at low temperature allows the ascorbic acid to pass to blanching liquid as it is a water soluble constituent. Gleim et al. (1944) concluded that there is oxidation of ascorbic acid during processing, when it is released in the blanching solution. Sulpher-dioxide is a strong reducing agent and gets reduced earlier than the ascorbic acid and thus gives protection to ascorbic acid. Malekar and Banerjee (1959) studied the retention of ascorbic acid during blanching and found that blanching the vegetable in sulphite solution was the best method for ascorbic acid retention and better culinary quality.

4.1.3 Effect on beta carotene :

The data regarding the beta carotene loss during blanching and subsequent drying presented in Table 1 reveal that there was a loss of 48.08 per cent beta carotene in unblanched product which was maximum amongst all the treatments of sun-drying method. Blanching without any chemical for two minutes, three minutes and five minutes at boiling, 90°C and 80°C temperature respectively also minimised the loss as compared to unblanched control.

There was as much as 48.08 per cent loss of beta carotene in sun-dried control product and the loss was gradually reduced through different treatments and it was minimum viz. 11.02 per cent in a sample which was blanched at boiling temperature for two minutes in a solution of 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$.

As regards the effectiveness of chemicals used in blanching, it was observed that 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ was far better followed by the other chemical combination and no chemicals in that order. The high-temperature short-time (HTST) processing was found to be better than medium temperature medium-time (MTMT) processing and low-temperature long-time (LTLT) processing in both methods of drying.

The cabinet-drying method proved to be superior over sun-drying method in respect of carotene retention. The loss of beta carotene was 48.08 per cent in sun-dried product as against 37.73 per cent in cabinet-dried product thus indicating the superiority of cabinet-drying over sun-drying method. The minimum loss of beta carotene was observed to be 8.55 per cent in a cabinet-dried sample blanched at boiling temperature with KMS, MgO and $NaHCO_3$ combination, whereas, the loss was 11.02 per cent for the same treatment in sun-drying method.

Although, the beta carotene is not water soluble constituent, the losses are due to heat and oxidation during blanching and subsequent drying. The rupturing of chromoplasts is more in case of LTLT method than the HTST method due to which there are more losses at lower temperature in both the methods of drying.

The above results are identical with those obtained by Gleim and Tressler (1944) who reported that losses of carotene are due to heat during blanching and drying. Patil (1976) concluded that blanching helps in retaining beta carotene. The HTST method with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ in cabinet-drying retained maximum amount of beta carotene than any other method of processing and drying. Salem and Hegazi (1973) found that slow drying causes greater losses of carotene than the vacuum drying method.

4.1.4 Effect on drying ratio :

The blanched sample had lower drying ratio than the unblanched ones, as seen from the data presented in Table 1, which further reveals that there is considerable difference in dry weight obtained from different treatments of drying. It is much wider in a sun-dried control i.e. 1:16 and it gradually narrowed through different treatments and there was maximum dry weight obtained (1:12.07) in the treatment which was blanched at boiling temperature for two minutes with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$.

The chemical combination for 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ proved very effective in lowering down the drying ratio. The next best alternative for lowering the drying ratio was 2.0 per cent NaCl + 0.2 per cent KMS set of chemicals which was better than the tap water blanching. It was also found that the HTST method is superior over MTMT and LTLT methods for bringing down the ratio.

As regards the effect of drying method on drying ratio the data clearly indicate that the cabinet-drying method is far better than the sun-drying method. In sun-drying control sample the ratio was 1:16, which is wider than any other ratio including sun-dried as well as cabinet-dried ones. The combination of boiling temperature for two minutes with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ in cabinet dried sample lowered drying ratio to the minimum of 1:11.06 as against 1:12.07 in sun-dried sample having the same treatment.

The above findings are in agreement with those of Weiser (1962) and Patil (1976). Weiser (1962) reported that the drying ratio is higher in unblanched product than that of blanched product while Patil (1976) who stated that the HTST method with chemical preservatives like KMS, MgO, NaCl and $NaHCO_3$ effectively brought down the drying ratio when dried in cabinet-drier.

4.1.5 Effect on chlorophyll during storage :

The treated samples along with control product were stored at room temperature for a period of three months and were analysed for chlorophyll, ascorbic acid and beta carotene content. The losses were calculated with reference to their original content in fresh samples on dry weight basis. The results are embodied in Tables No.2, 3 and 4 and graphically represented in Fig.2, 3 and 4 respectively.

A perusal of the data in Table 2 will reveal that there was maximum loss of chlorophyll viz. 67.78 per cent in unblanched sun-dried sample at the end of a month's storage. There was a steady reduction in the loss of chlorophyll from unblanched sample towards blanched samples with or without chemicals in blanching water.

Among the time-temperature regimes the HTST was better than the MTMT and LTLT with chemicals or without chemicals. Similarly the chemical combination of 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ was better than 2.0 per cent NaCl + 0.2 per cent KMS and no chemical blanching in that order. The best treatment for maximum retention of chlorophyll was the

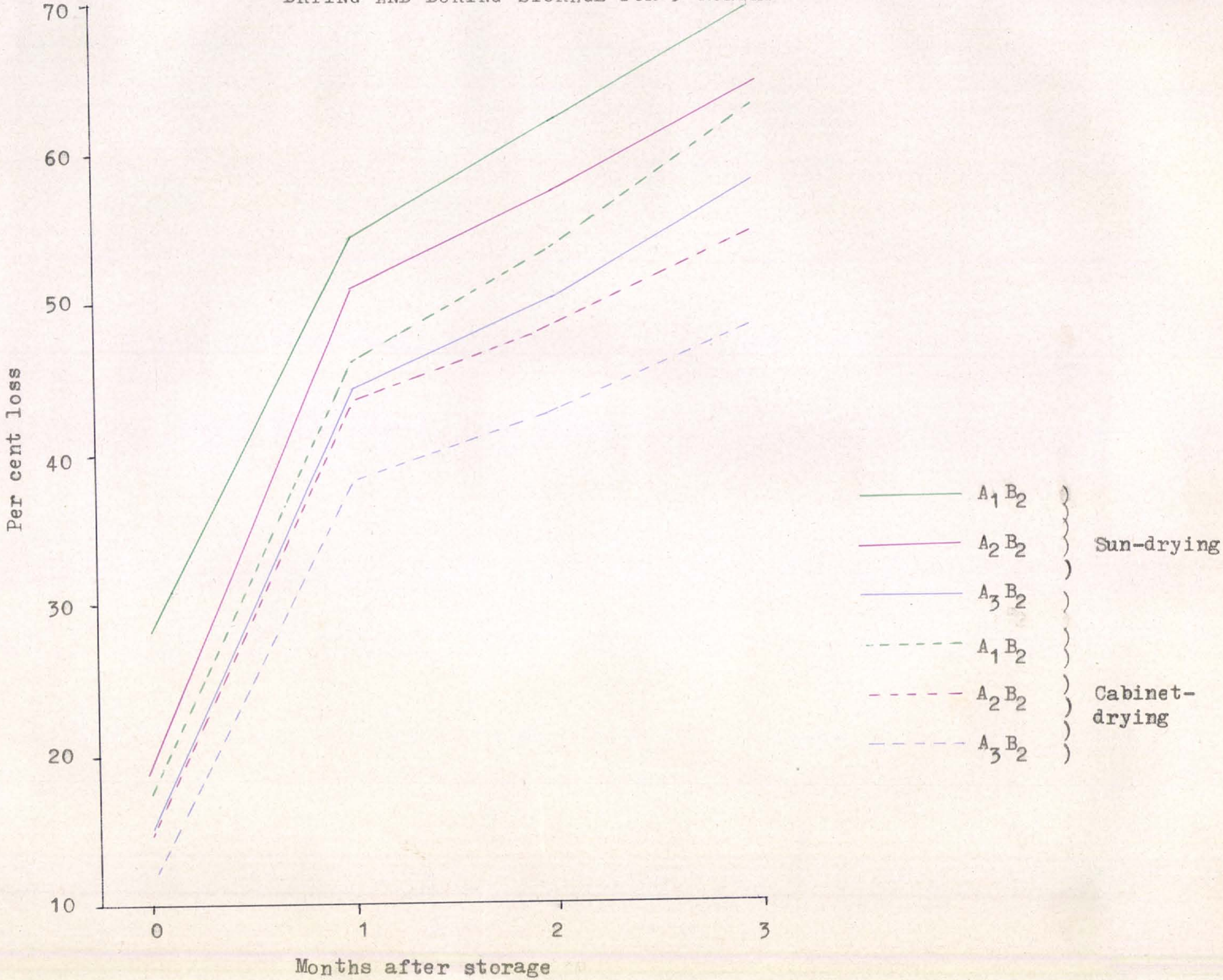
Table 2 : Data regarding per cent loss of chlorophyll in spinach during storage in sun-dried and cabinet-dried products (values calculated on dry weight basis).

Treatment symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet-dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	67.78	76.47	83.99	58.91	71.55	78.42
A_1B_0	63.07	73.08	78.86	54.94	65.67	73.01
A_1B_1	60.21	67.17	74.12	51.22	58.43	67.94
A_1B_2	54.26	62.00	69.52	45.70	53.88	62.90
A_2B_0	61.23	68.78	74.85	52.00	59.90	68.87
A_2B_1	55.000	62.94	70.00	47.12	55.04	59.72
A_2B_2	50.90	56.99	64.29	43.33	48.53	54.89
A_3B_0	58.66	64.87	70.96	50.02	54.01	65.28
A_3B_1	52.77	58.56	67.42	44.04	49.26	56.98
A_3B_2	44.13	50.26	57.95	37.95	42.80	48.43

one which was blanched with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ at boiling temperature.

Similar trend of chlorophyll loss was observed in all the treatments under sun-drying at the end of two months storage. But there was a further loss of chlorophyll in each sample whether blanched with or without chemicals. However, there was a much less loss as compared to unblanched control and the same treatment of boiling water blanching with three chemicals for two minutes was better than all other treatments and the loss

DRYING AND DURING STORAGE FOR 3 MONTHS



was to the extent of only 50.26 per cent as compared to 76.47 per cent in unblanched control.

At the end of three months storage also a similar trend in chlorophyll loss was observed in the treatments under sun-drying. The chlorophyll losses were further increased in all the treatments. Even then the treatment of blanching with three chemicals at boiling temperature for two minutes had the minimum loss of 57.95 per cent against the 83.99 per cent in unblanched control which is also quite evident from Plate II(2) and I(2). All the treated samples retained more chlorophyll than the unblanched sun-dried sample.

As regards the method of drying all the cabinet-dried samples retained more chlorophyll than the sun-dried samples under each treatment (Plate I). An unblanched sun-dried sample lost as much as 67.78 per cent, 76.47 per cent and 83.99 per cent as against 58.91 per cent, 71.55 per cent and 78.42 per cent respectively at the end of 1st, 2nd and 3rd month's storage of unblanched cabinet-dried sample. The use of three chemicals in blanching water helped to reduce the chlorophyll loss to the maximum extent followed by the use of two chemicals. The samples blanched without chemicals at all the time -temperature regimes also were superior to the unblanched cabinet-dried samples as in sun-dried samples. There was as little as 48.43 per cent loss of chlorophyll in the sample blanched with three chemicals at boiling temperature for two minutes, as against 83.99 per cent of the unblanched product at the end of the same period i.e. 3 months of storage (Plates I(2) and II(1).

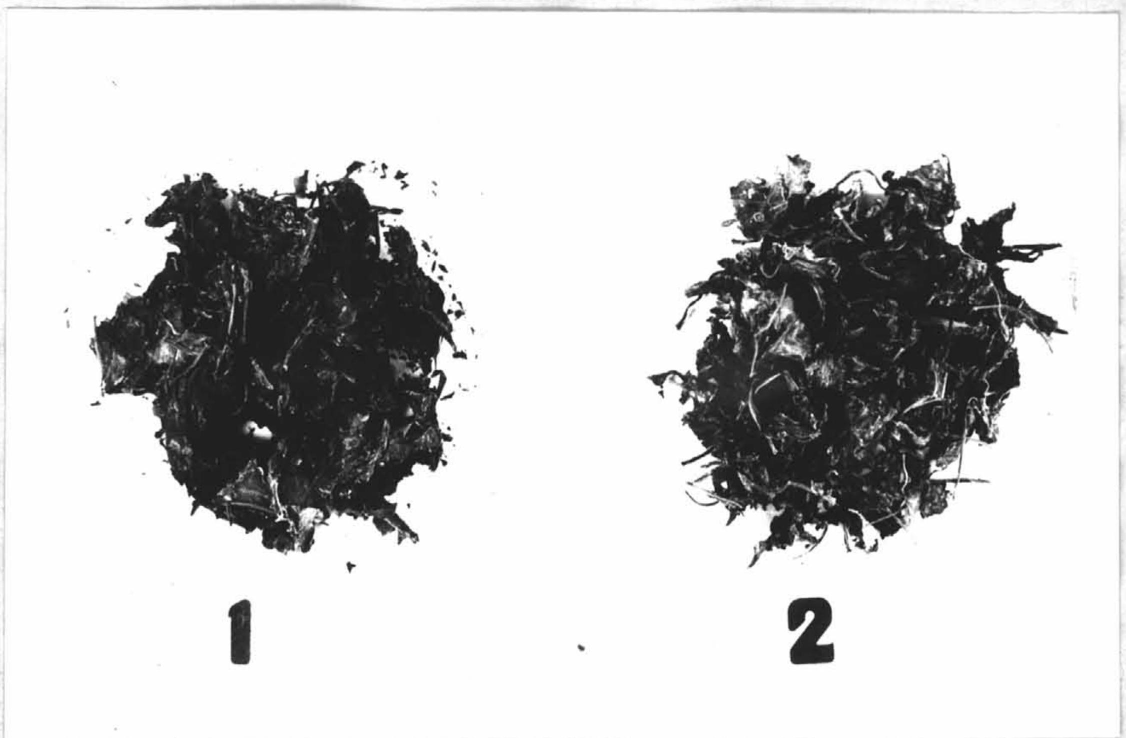
However, the rate of loss of chlorophyll after storage was more in treated samples as compared to unblanched control as can be seen from the values given in Table 1. The loss of chlorophyll immediately after treatment was 53.74 per cent in unblanched control which increased to 83.99 per cent (30.25 per cent further loss during storage) while the original loss of 11.59 per cent in the best treatment under cabinet-drying was enhanced to 48.43 per cent (an increase of 36.89 per cent) at the end of the same period of storage. This could be attributed to the heavy loss of chlorophyll in the unblanched sample in the beginning.

From the above results it is very clear that without blanching there is no inactivation of enzymes which results in loss of chlorophyll during drying and subsequent storage. Blanching helps in controlling the oxidation of chlorophyll. Wegenknecht (1952) reported that chlorophyll is de-colourised due to oxidative reaction. The alpha hydroxy-acid dehydrogenase system in green plants oxidises glycolic acid which causes de-colourisation of chlorophyll. Bhatia et al. (1963) stated that chemical preservatives are essential during blanching for preserving chlorophyll in storage. According to Patil (1976) there is more loss of chlorophyll in sun-dried product than that of cabinet-dried product. He further explains that during the sun-drying there is free and open air which must be accelerating the rate of oxidation which is not the case with the cabinet-drying.

PLATE I

1. Cabinet-dried control product of spinach
2. Sun-dried control product of spinach

PLATE II



1. Cabinet-dried product, blanched with 0.5% KMS + 0.1% MgO + 0.1% $NaHCO_3$ at boiling temperature.

2. Sun-dried product, blanched with 0.5% KMS + 0.1% MgO + 0.1% $NaHCO_3$ at boiling temperature

4.1.6 Effect on ascorbic acid during storage :

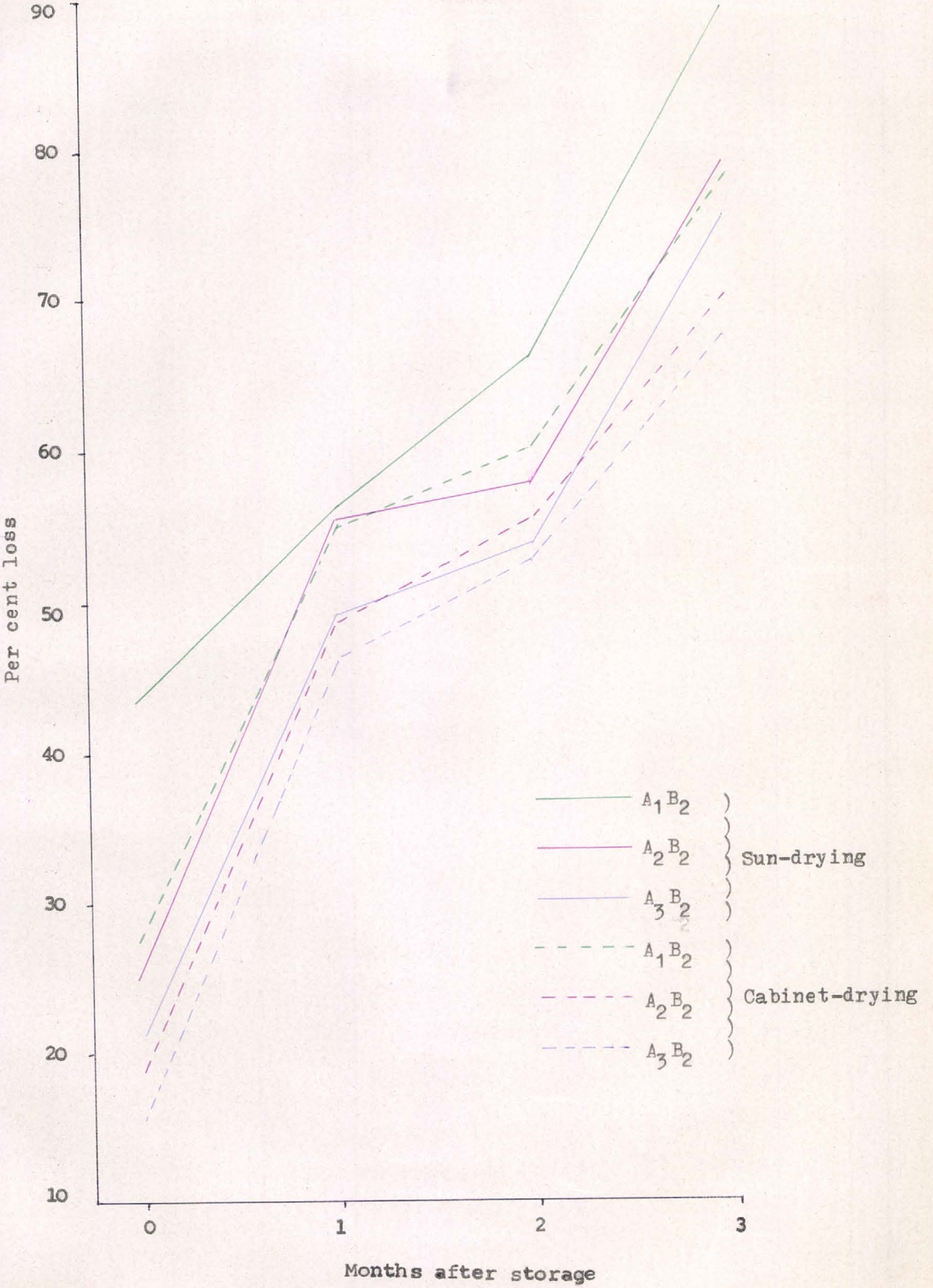
The data presented in Table 5 reveal that there was maximum loss of ascorbic acid viz. 84.92 per cent in unblanched sun-dried control sample at the end of first month's storage. There was a gradual reduction in the loss of ascorbic acid from unblanched samples towards the blanched samples with or without chemical.

Table 5 : Per cent loss of ascorbic acid of spinach in sun-dried and cabinet-dried product during storage. (Values calculated on dry weight basis).

Treatment symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet-dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	84.92	96.01	100.00	79.12	90.91	100.00
A_1B_0	76.88	80.06	93.20	70.05	76.94	85.97
A_1B_1	71.54	78.22	90.70	67.07	68.88	81.16
A_1B_2	56.01	66.03	89.06	54.97	60.00	78.04
A_2B_0	67.00	70.41	87.05	59.14	65.03	79.99
A_2B_1	62.01	64.09	81.09	51.01	59.19	74.09
A_2B_2	55.30	57.07	79.01	48.78	55.20	70.13
A_3B_0	61.54	67.19	85.07	58.02	61.18	76.77
A_3B_1	55.53	58.83	79.17	50.30	58.02	71.16
A_3B_2	49.04	53.61	75.21	46.00	52.35	67.20

As regards the time-temperature combination, the HTST method was better than the MTMT and LTLT methods with or without

Fig. 3 : Loss of ascorbic acid in sun- and cabinet-dried spinach after drying storage for three months



chemicals. The most effective chemical combination for retaining maximum ascorbic acid during storage was found to be the one blanched with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$, which was followed by 2.0 per cent NaCl + 0.2 per cent KMS blanching and no chemical blanching. The top most treatment for maximum retention of ascorbic acid was the one which was blanched with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ at boiling temperature during first month's storage in both the methods of drying.

Similar trend of ascorbic acid loss was observed in all the treatments under sun-drying at the end of two month's storage. However, there was a further increase in loss of ascorbic acid in each sample of treated as well as untreated ones. There was much more loss of ascorbic acid in unblanched product than that of treated with or without chemicals. The treatment of boiling temperature blanching with KMS, MgO and $NaHCO_3$ set was better than all other treatments and the loss was to the extent of only 53.61 per cent as against the heavy loss of 96.01 per cent in unblanched sample.

At the end of three months also a similar trend of ascorbic acid loss was observed in the treatment under sun-drying. The ascorbic acid losses were further increased in all the treatments. The amount of ascorbic acid lost in blanched treatment with KMS, MgO and $NaHCO_3$ was the lowest as compared to the other set of chemicals and tap water blanching. The maximum loss was observed in control sample viz. 100 per cent, whereas, it was minimum viz. 75.21 per cent in a sample blanched with KMS, MgO and $NaHCO_3$ at boiling temperature for two minutes. The trend of blanching, chemicals and HTST processing remained the same in cabinet-drying also.

As regards the method of drying, all the cabinet-dried samples retained more ascorbic acid than sun-dried samples under any treatment. The loss of ascorbic acid in unblanched sun-dried sample was as much as 84.92, 96.01 and 100 per cent as against the corresponding figures of 79.12, 90.91 and 100.00 per cent at the end of first, second and third month's storage respectively of unblanched cabinet-dried sample. In this case the cabinet-drying proved to be superior to sun-drying upto second month but at the end of third month both were similar as in both methods there was cent per cent loss of ascorbic acid. The A_3B_2 treatment retained maximum amount of ascorbic acid in both the methods of drying but the amount retained was more in case of cabinet-dried than that of sun-dried sample, thus indicating the superiority of cabinet-drying over sun-drying.

As the ascorbic acid is oxidative in nature, it is very difficult to preserve during storage. Even then it was retained upto the maximum extent in sulphited products at the end of 3rd month. The reason may be that the sulphur dioxide gave strong protection to the product preventing the oxidation of ascorbic acid by releasing itself slowly and getting reduced in place of ascorbic acid. Cruess (1943) also reported that blanching before dehydration in sulphur dioxide or with bisulphite helps in retaining more vitamin (ascorbic acid) during storage. He further stated that the loss of vitamin C in most of the dehydrated vegetables without blanching was severe and could be even 100 per cent within a few weeks of storage. Singh (1973) found that 0.3 per cent KMS in blanching solution avoided browning of cabbage after dehydration and retained maximum amount of ascorbic acid during subsequent storage. This was latter confirmed by Patil (1976). As regards other blanched treatments which retained some ascorbic acid even at the end of three month's storage, it can be said that the biological systems which cause degradation of ascorbic acid were denatured at various blanching temperatures and as such the process of degradation was slowed down (Annon, 1974).

4.1.7 Effect of storage on beta carotene :

The data presented in Table 4 clearly indicate that there was maximum loss of beta carotene viz. 53.12 per cent in unblanched sun-dried sample at the end of a month's storage. There was a gradual reduction in the loss of beta carotene from unblanched sample towards those blanched with or without chemicals at any time-temperature and chemical combination. The same trend was also observed in cabinet-dried samples.

As regards the time temperature effect for conserving more carotene during storage the high-temperature short-time method (HTST) was better than the MTMT and LTLT methods, coupled with any set of chemicals. As regards the effectiveness of chemical combinations, it was found that both sets of chemicals were helpful in retaining beta carotene during storage but the KMS,

Table 4 : Per cent loss of beta carotene of spinach in sun-dried and cabinet-dried products during storage (Values calculated on dry weight basis).

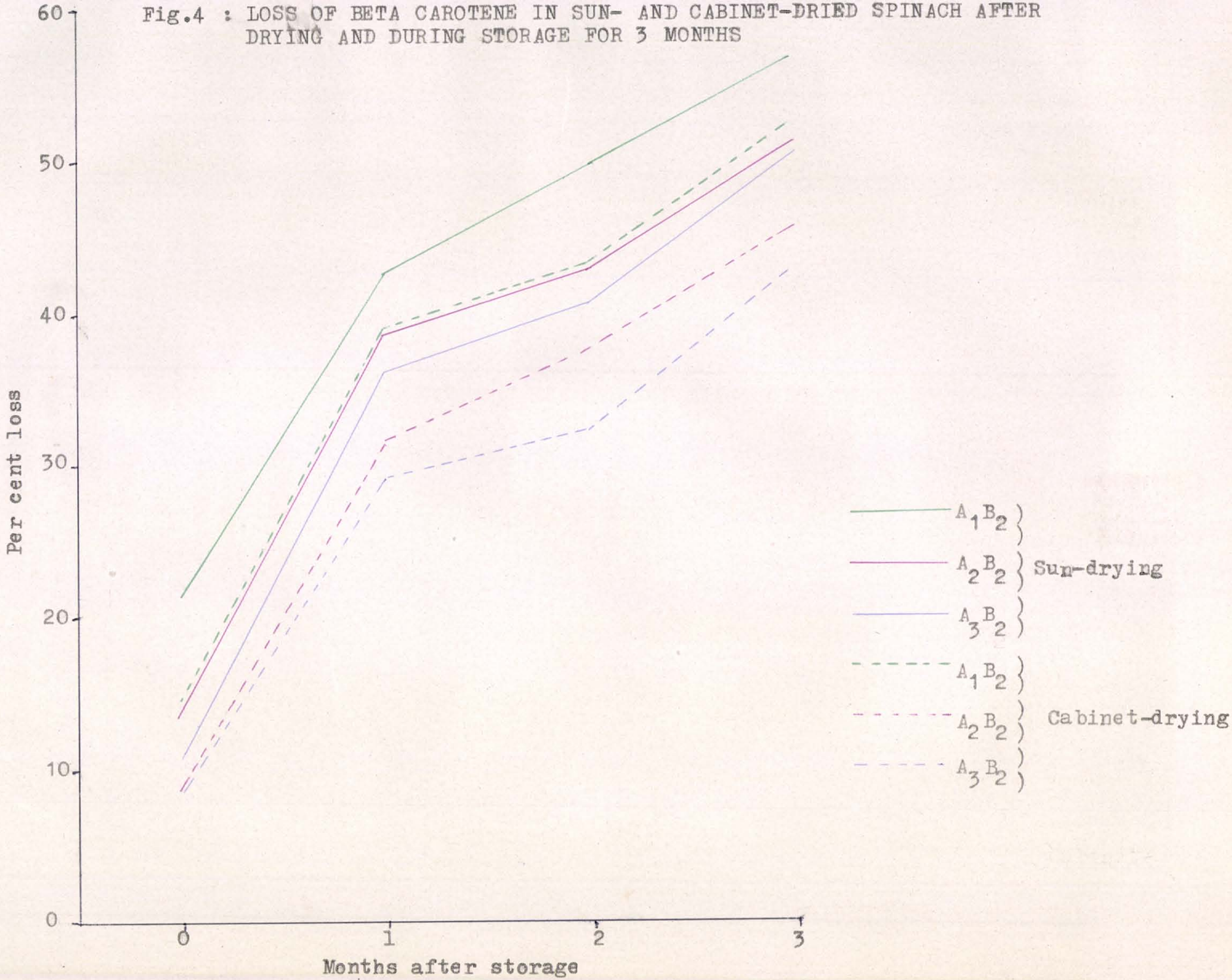
Treatment symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet-dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	53.12	65.17	74.55	48.66	55.52	66.22
A_1B_0	48.35	58.35	65.00	43.77	48.60	59.25
A_1B_1	47.25	54.72	61.15	42.52	46.22	57.50
A_1B_2	42.87	50.00	56.62	38.98	43.50	52.72
A_2B_0	42.73	51.23	58.76	40.18	45.06	52.38
A_2B_1	39.63	46.86	53.40	36.40	40.30	49.38
A_2B_2	38.56	42.93	51.36	31.23	37.83	45.78
A_3B_0	42.54	49.71	56.91	38.56	44.96	50.08
A_3B_1	38.08	44.74	53.58	32.45	37.13	45.51
A_3B_2	36.11	40.82	50.31	29.18	32.20	42.82

MgO and $NaHCO_3$ set was superior over the other set in both, sun- as well as cabinet-drying methods. The best treatment viz. A_3B_2 which was blanched at boiling temperature with three chemicals for two minutes lost 36.11 per cent of carotene in sun-drying and 29.18 per cent in cabinet-drying.

This was followed by the treatment blanched with the set of two chemicals, which in turn was followed by tap water blanching in retention of higher quantity of beta carotene.

Similar trend of beta carotene loss was observed in all the treatments under sun-drying as well as caninet-drying at

Fig.4 : LOSS OF BETA CAROTENE IN SUN- AND CABINET-DRIED SPINACH AFTER DRYING AND DURING STORAGE FOR 3 MONTHS



the end of two months' storage. There was increases in loss in all the treated as well as control samples. However, there was much less loss observed in a treated sample than the control one. The same treatment viz. A_3B_2 retained maximum carotene viz. 40.82 per cent and 32.20 per cent in sun-dried and cabinet-dried samples respectively at the end of second month. This treatment was followed by A_2B_2 and A_1B_2 in that order in both the methods of drying.

At the end of three months' storage also a similar trend in beta carotene loss was observed in both the methods. The carotene losses were further increased in all the treatments. Even then the treatment A_3B_2 had the minimum loss of carotene viz. 50.31 per cent and 42.82 per cent in sun-drying and cabinet-drying respectively. All treated samples retained more carotene than control sample but the amount retained by chemical blanching was more than that of tap water blanching treatment.

As regards the method of drying, all the cabinet-dried products retained more carotene than the sun-dried ones. A blanched sample A_3B_2 which was best among all the treatments, retained 36.11, 40.82 and 50.31 per cent of beta carotene under sun-drying at the end of 1st, 2nd and 3rd month's storage as against 29.18, 32.20 and 42.82 per cent for the respective period of storage in cabinet-drying, thus indicating that the cabinet-drying is better than sun-drying method both for treated as well as untreated samples.

As regards the rate of loss of beta carotene after drying during storage, it was observed that the unblanched control sample of spinach lost 48.08 per cent of beta carotene immediately after drying which increased to 53.12 per cent at the end of first month's storage (an increase of 5.04 per cent) as against the A_3B_2 treatment where the loss was increased by 25.09 per cent for the same period. This is due to the maximum loss of carotene during drying of control sample which, therefore, loses less beta carotene during the first month in storage.

The above results coincide with those obtained by Thelma (1944), Morgan (1944), Feinberg (1973), Salem and Hegazi (1973) and Patil (1976) in respect of blanching effect, chemical preservatives and drying method.

4.1.8 Rehydration :

The object behind rehydration was to find out the water absorbing capacity of the dried product under different sets of treatments. The rehydration was done by dipping 5 g of dried sample in 100 ml of hot water having 75°C temperature. The product was kept in water until it became soft enough and attained its full turgidity. It took on an average about one hour in all samples to reach this point. After dipping for one hour the water was completely drained out. The rehydration ratio was calculated by dividing the turgid weight by dry weight. The data are presented in Table 5. The data reveal that there was no much difference between blanched and unblanched samples of dried material in respect of rehydration ability in both the methods of drying. The unblanched samples of both the methods of drying absorbed more water than the blanched products which were treated by LTLT and MTMT processing methods, thus indicating that the LTLT and MTMT methods render the product hard which may help in preserving the product for a longer time in storage.

Table 5 : Rehydration ratio of spinach

Treatment	Sun-dried product	Cabinet-dried product
A_0	3.40	3.48
A_1B_0	2.01	2.40
A_1B_1	2.20	2.23
A_1B_2	3.15	3.16
A_2B_0	2.40	2.81
A_2B_1	2.35	2.36
A_2B_2	3.50	3.61
A_3B_0	2.80	2.89
A_3B_1	2.85	3.00
A_3B_2	3.55	3.70

As regards the use of chemical preservatives for increasing the water absorbing capacity there was no remarkable difference between the two sets of chemicals. However, the KMS, MgO and $NaHCO_3$ combination absorbed slightly higher quantity of water than the other combination. The samples treated with or without chemicals at 80°C $\pm$ 1°C and 90°C $\pm$ 1°C temperature absorbed less water than the control sample in both the methods of drying. The sample blanched at boiling temperature for two minutes with chemicals absorbed more water than the control sample.

About the effectiveness of drying method for increasing the rehydration ratio there was no considerable different in between sun-drying and cabinet-drying; however, the cabinet-drying slightly increased the rehydration capacity than the sun-drying method. In control samples of sun-drying the ratio was 3.40 as against 3.48 in cabinet-drying. The best treatment was A_3B_2 which absorbed and held more water as can be seen from its rehydration ratios of 3.55 and 3.70 in sun-drying and cabinet-drying respectively.

The above findings fairly agree with those obtained by Teaotia and Awasthi (1968). They reported that the 0.2 per cent sulphiting treatment to jack fruit bulb during blanching gave better rehydration ratio. Patil (1976) also found that the cabinet-drying method gave maximum rehydration yield when the samples were blanched with KMS, MgO and $NaHCO_3$ chemicals.

4.1.9 Culinary quality of the product :

The culinary quality of the product was assessed by a panel of 5 judges in respect of colour, texture, flavour, appearance and taste of prepared vegetable. The data on the scores of different treatment products are summarised in Table 6. A perusal of the data will reveal that various organoleptic test parameters of products, scored differently for each treatment. The unblanched product in both the methods of drying secured the lowest marks than the blanched product with or without chemicals. The sun-dried products secured less marks in each

Table 6 : Culinary quality of sun-dried and cabinet-dried products of spinach

Treatment symbol	Sun-dried product						Cabinet-dried product					
	Colour (15)	Texture (15)	Flavour (15)	Appearance (15)	Taste (40)	Total (100)	Colour (15)	Texture (15)	Flavour (15)	Appearance (15)	Taste (40)	Total (100)
A_0	4	6	5	4	20	39	5	6	6	7	20	44
A_1B_0	4	6	7	5	22	44	4	7	9	9	25	54
A_1B_1	6	6	7	4	24	47	7	9	10	9	27	62
A_1B_2	8	10	8	6	23	55	9	8	9	8	27	61
A_2B_0	7	10	9	6	25	57	8	10	10	10	27	65
A_2B_1	8	10	10	8	25	61	12	12	12	9	29	74
A_2B_2	8	11	9	9	24	61	11	12	12	9	30	74
A_3B_0	8	10	12	10	27	67	10	11	12	10	28	71
A_3B_1	9	11	10	9	26	65	12	12	12	11	29	76
A_3B_2	10	11	12	10	27	70	12	12	13	13	33	83

aspect viz. colour, flavour, texture and taste. The colour of control product was very faint due to which the appearance was unattractive. The taste of control product was not too bad as against the blanched product.

As regards the effect of chemicals on culinary quality, the blanched samples with chemicals scored higher marks than the water blanched samples in both the methods of drying. Among the chemical sets, the KMS, MgO and $NaHCO_3$ set secured maximum marks than the other set of chemicals. There was no remarkable difference found in the methods of processing. However, the high-temperature short-time method secured more marks than the MTMT and LTLT methods of processing.

There was considerable difference in sun-dried and cabinet-dried products in respect of colour, flavour and appearance. All cabinet-dried products including the control one secured more marks than the sun-dried product under the same set of treatments. The cabinet-dried product had dark green colour and thus had a good appearance, whereas, the sun-dried product lost its colour during storage and after cooking, the sample became pale yellow. The best treatment was A_3B_2 which was blanched at boiling temperature with KMS, MgO and $NaHCO_3$ chemical combination. It secured maximum marks i.e. 83 and 70 per cent in cabinet-drying and sun-drying methods respectively. This treatment was superior over each aspect of test against the other treatments in both the methods of drying.

4.2 Gram leaves :

Effect of blanching, chemical preservatives, time-temperature combination and drying method on the retention of chlorophyll, ascorbic acid, beta carotene and drying ratio after drying on gram leaves were studied and the data are presented in Table 7 and graphically represented in Fig. 5.

4.2.1 Effect on chlorophyll :

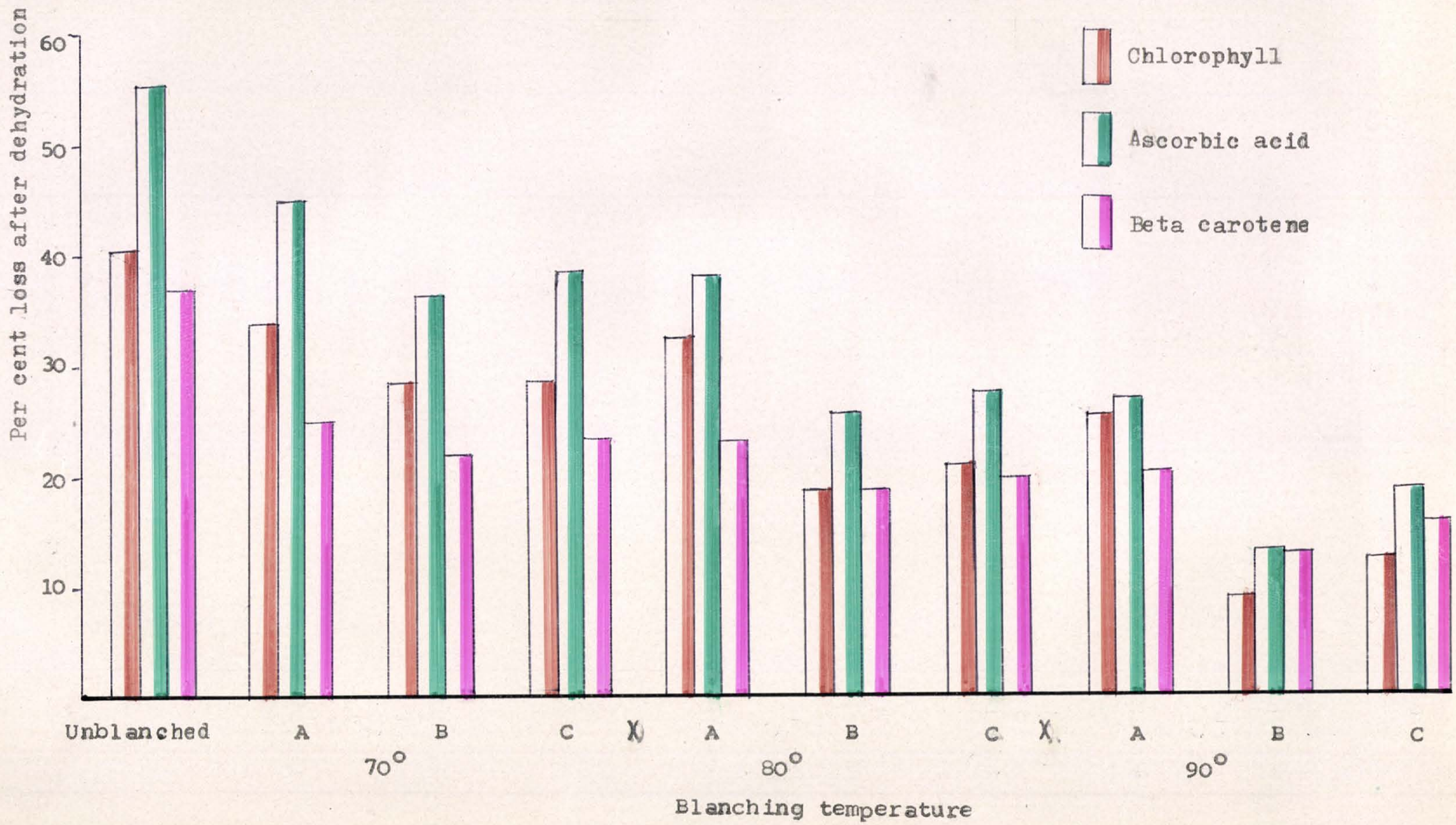
The data reveal that there was severe loss of chlorophyll in unblanched product as compared to blanched one with or without various chemicals at different time-temperature combinations. There was as much as 51.00 per cent loss in sun-dried control product and the loss was gradually reduced through different treatments and it was minimum i.e. 12.15 per cent in a treatment which was blanched at 90°C ± 1°C temperature for two minutes with 2.0 per cent NaCl + 0.2 per cent KMS.

As regards the chemicals used in blanching process, it was observed that 2.0 per cent NaCl + 0.2 per cent KMS was a better combination of chemical preservatives. Next to above the chemical combination of 0.5% KMS + 0.1 per cent MgO + 0.1 $NaHCO_3$ was found to be good followed by water blanching treatment in comparison with unblanched products. Among the methods of blanching, it was observed that HTST method was superior over MTMT and LTLT methods with or without chemicals as there was gradual reduction in the loss of chlorophyll content with these combinations from LTLT through HTST Method.

Table 7 Data on the effect of various treatments on gram leaves (Values calculated on dry weight basis).

Treatment symbol	Chlorophyll % loss		Ascorbic acid % loss		Beta carotene % loss		Drying ratio	
	Sun-drying	Cabinet-drying	Sun-drying	Cabinet drying	Sun-drying	Cabinet-drying	Sun-drying	Cabinet-drying
A_0	51.00	40.45	69.92	55.41	49.09	37.11	1:7.50	1:6.65
A_1B_0	43.92	33.42	55.52	45.04	30.48	24.97	1:6.80	1:6.30
A_1B_1	39.00	32.45	51.78	37.83	28.15	22.53	1:6.20	1:5.75
A_1B_2	31.08	25.56	46.28	26.99	25.79	20.32	1:4.90	1:4.45
A_2B_0	32.01	28.79	45.57	36.61	27.27	22.08	1:5.00	1:4.55
A_2B_1	23.13	18.43	37.42	25.35	20.08	18.36	1:4.55	1:4.12
A_2B_2	12.15	8.95	25.91	13.49	16.95	12.93	1:4.05	1:3.55
A_3B_0	37.98	28.76	46.26	38.88	27.96	23.15	1:5.30	1:4.85
A_3B_1	28.72	21.06	39.37	27.55	22.08	19.66	1:4.75	1:4.30
A_3B_2	18.04	12.38	30.30	18.63	20.54	15.49	1:4.35	1:3.98

Fig. 5 : Effect of blanching with or without chemicals on chlorophyll ascorbic acid and beta carotene in cabinet dried gram leaves



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The data of the same Table further indicate that the cabinet-drying method is helpful for retaining more chlorophyll than the sun-drying method. The loss of chlorophyll in sun-drying control method was 51.00 per cent, whereas, in cabinet-drying control product, it was only 40.45 per cent immediately after drying.

The above findings are in agreement with those obtained by Dietrich (1958), Gupte and Francis (1964), Van et al. (1964) and Dutton (1943). Dietrich (1958) observed that there was conversion of chlorophyll to pheophytin during processing. Wagen Knecht et al. (1978) found that blanching helped in preserving chlorophyll. According to Dietrich (1965), as the duration of blanching increases, the losses of chlorophyll also increase. Gupte et al. (1964) found that spinach processed by HTST method retained more chlorophyll than that by LTLT method. Bhatia (1963) concluded that chemical preservatives like $NaHCO_3$, MgO, KMS were helpful in minimising the chlorophyll losses during blanching and subsequent drying of peas.

4.2.2 Effect on ascorbic acid :

The data in respect of above constituent in Table 7 reveal that there was considerable loss of ascorbic acid in unblanched product i.e. 69.92 per cent of sun-dried control as compared to blanched product with or without chemical in any time-temperature combination. The maximum loss viz. 69.92 per cent was observed in sun-dried control and gradually it lowered down upto 25.91 per cent in a sample blanched at 90°C ± 1°C temperature with 2.0 per cent NaCl + 0.2 per cent KMS for 2 minutes.

When the effectiveness of chemical is considered, the combination of 2.0 per cent NaCl + 0.2 KMS was better followed by the other set of chemicals viz. 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ and tap water blanching in that order. As regards the time-temperature combination the high-temperature short-time (HTST) blanching was better than medium temperature for medium time and low temperature for long time blanching with or without chemical in both the methods of drying.

Similar trend of reduction in ascorbic acid loss was observed in cabinet-drying which was superior to sun-drying in each of the treatment combinations. The loss of ascorbic acid was 55.41 per cent in cabinet-dried product, which was unblanched control as against 69.92 per cent in sun-dried control. The minimum loss of ascorbic acid was observed to be 25.91 per cent in A_2B_2 treatment of sun-drying method which was further lowered down to 13.49 per cent in cabinet-drying for the same time, temperature and chemical combination.

From the above brief account it is very clear that the blanching by HTST method with chemical preservatives coupled with cabinet-drying is helpful for retaining maximum amount of ascorbic acid. These findings are in agreement with the findings of several workers. Eheart _et al_. (1945) reported that blanched beans were richer in ascorbic acid than the unblanched ones. Malekar and Banerjee (1959) studied the retention of ascorbic acid during blanching and concluded that blanching in sulphite solution was the best method for retention of ascorbic acid in vegetables.

In case of 2.0 per cent NaCl + 0.2 per cent KMS blanching, the leaching of ascorbic acid was prohibited. The chemical combination gives protection to the ascorbic acid as KMS gets reduced first. As a result there are less losses of ascorbic acid which were blanched with these chemicals. Cruess (1943) found that the ascorbic acid was well retained when the vegetable was sulphited before drying. According to Singh (1973) blanching with 0.3 per cent KMS was good for avoiding browning of cabbage after dehydration while Patil (1976) reported that use of chemicals during blanching helped in controlling the loss of ascorbic acid. He further reported that the high-temperature short-time method of processing was superior over LTLT method for retaining more ascorbic acid. Salem and Hagasi (1973) reported that the sun-drying caused more loss of vitamin than the quick vacuum drying.

4.2.3 <u>Effect on beta carotene</u> :

The data presented in Table 7 reveal that the highest loss of beta carotene was found in unblanched control sample as compared to blanched product with or without various chemicals at different time-temperature combinations. There was as much as 49.09 per cent loss in sun-dried control sample but when the blanching was done with various chemicals, different time-temperature combinations was gradually reduced and was observed to be minimum i.e. 13.49 in a treatment which was blanched at 90°C ± 1°C temperature with 2.0 per cent NaCl + 0.2 per cent KMS solution.

Among the various chemicals used in blanching solution, it was observed that 2.0 per cent NaCl + 0.2 per cent KMS combination was superior over the other set of chemicals and over no chemical blanching. It is also evident from Table 7 that the A_2B_2 treatment in sun-drying allowed the loss upto 12.93 per cent only as against 15.49 per cent in A_3B_2 treatment and 25.79 per cent in A_1B_2 treatment which was water blanching thus indicating that the A_2B_2 treatment i.e. 2.0 per cent NaCl + 0.2 per cent KMS is most effective in controlling the loss of beta carotene. As regards the time temperature combination the 90° ± 1°C for 2 minutes was superior over both the other temperature with any chemical set or no chemical, in both the methods of drying. It was followed by MTMT and LTLT methods in that order.

The reduction trend of loss of beta carotene, which was observed in cabinet-drying proved superior over the sun-drying in each of the treatment combinations. The loss of beta carotene in cabinet-dried control samples was 37.11 per cent as against 49.09 per cent in sun-drying control product, thus showing the effectiveness of cabinet-drying in retaining beta carotene.

The results obtained by Morgon (1944) fairly agree with those obtained in this study. He reported that the dehydration of mustard green and spinach lost their beta carotene to the extent of 27 per cent & 26 per cent in unblanched spinach and mustard green sample respectively but there was no loss of carotene in blanched spinach sample and it was only 20 per cent in blanched mustard green sample.

Patil (1976) stated that the combination of KMS, MgO and $NaHCO_3$ with HTST method preserved maximum amount of carotenoid during blanching and dehydration. He also reported that the quick drying method was far better than the slow drying method for retaining beta carotene in fenugreek after drying.

4.2.4 Effect on drying ratio :

The data presented in Table 7 reveal that the blanched sample had lower drying ratio than the unblanched sample in both the methods of drying. In sun-drying control, the drying ratio was observed to be 1:7.50 in unblanched and it was minimum i.e. 1:4.05 in a treatment blanched with 2.0 per cent NaCl + 0.2 per cent KMS.

As regards the effect of chemical combination for bringing down the ratio, it was observed that 2.0 per cent NaCl + 0.2 per cent KMS gave the lowest drying ratio followed by the other set of chemicals and without chemical blanching. It is very clear from the data in the same Table that in cabinet-drying the ratio was lower than that of sun-drying. The treatment A_2B_2 in cabinet-drying gave the ratio 1:3.55 as against 1:4.05 in sun-drying of the same time-temperature and chemical combination. The above findings are in line with those of Weiser (1962) and Patil (1976). Weiser (1962) reported that the drying ratio was higher in unblanched product than that of blanched product while Patil (1976) stated that the HTST method with chemical preservatives like KMS, MgO, NaCl and $NaHCO_3$ effectively brought down the drying ratio when dried in cabinet-drier.

4.2.5 Effect of different treatments on retention of chlorophyll, ascorbic acid and beta carotene of gram leaves during storage for three months at room temperature :

The treated samples along with the control product were stored at room temperature for a period of three months and were analysed for chlorophyll, ascorbic acid and beta carotene content at the end of each month. The results obtained are presented in Tables 8, 9 and 10 and graphically represented in Fig.4, 5 and 6 respectively.

4.2.5.1 Effect on chlorophyll :

The data in respect of chlorophyll loss during the storage period, presented in Table 8 reveal that there was a severe loss of chlorophyll viz. 59.48 per cent and 52.87 per cent respectively in unblanched control of sun-dried and cabinet-dried products at the end of a month's storage. There was a gradual reduction in the loss of chlorophyll from unblanched samples towards blanched samples with or without chemicals in blanching water, as is evident from Plate III.

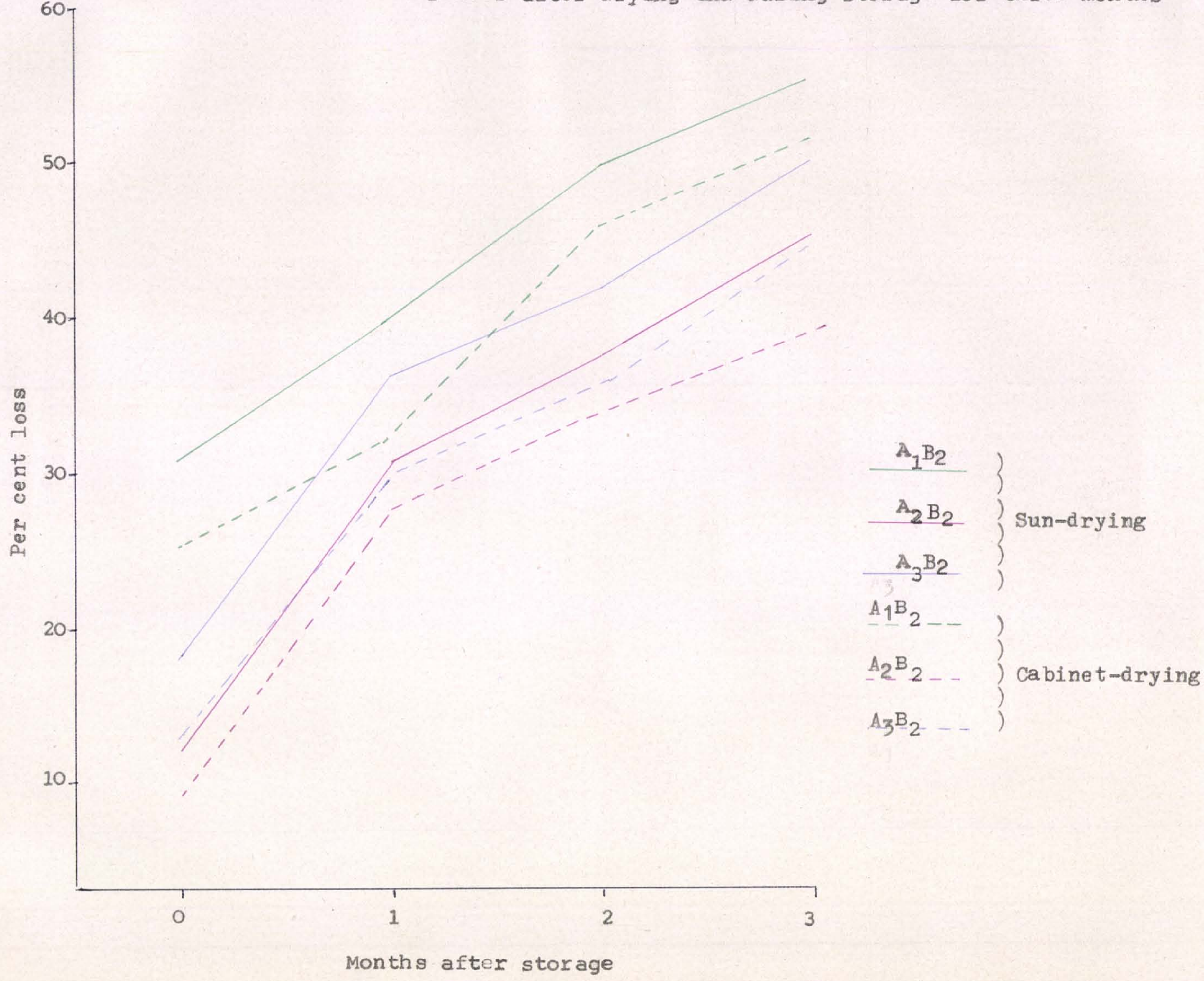
As regards the time-temperature regimes the HTST method was better than MTMT and LTLT methods with or without chemicals in both the methods of drying. Similarly the chemical combination of 2.0 per cent NaCl + 0.2 per cent KMS was found to be better followed by the other set of chemicals viz. 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ and no chemical blanching in that order.

Table 8 : Data regarding the per cent loss of chlorophyll of gram leaves in sun-dried and cabinet-dried peoducts during storage at room temperature (Values calculated on dry weight basis).

Treatment symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	59.48	68.27	73.05	52.87	61.01	64.96
A_1B_0	48.87	57.89	65.50	42.59	51.59	58.29
A_1B_1	42.72	53.53	59.92	36.01	47.69	53.25
A_1B_2	39.96	49.82	55.46	32.15	45.90	51.31
A_2B_0	45.47	51.81	57.28	35.01	42.98	48.10
A_2B_1	38.74	43.07	50.00	31.01	38.01	43.03
A_2B_2	30.85	37.47	45.14	27.17	34.03	39.11
A_3B_0	48.20	54.22	60.93	37.32	49.32	54.33
A_3B_1	41.79	46.22	54.85	35.95	42.88	47.06
A_3B_2	36.18	41.61	49.95	29.71	35.97	41.29

The best treatment for maximum retention of chlorophyll was A_2B_2 which was blanched with 2.0 per cent NaCl + 0.5 per cent KMS at 90°C ± 1°C temperature for two minutes. This treatment lost 30.85 per cent and 27.17 per cent of chlorophyll in sun and cabinet-dried samples respectively at the end of a month's storage.

The same trend of chlorophyll loss was observed in all the treatments in sun-drying as well as cabinet-drying at the end of two month's storage. The loss further increased in all the leaves after drying and during storage for three months



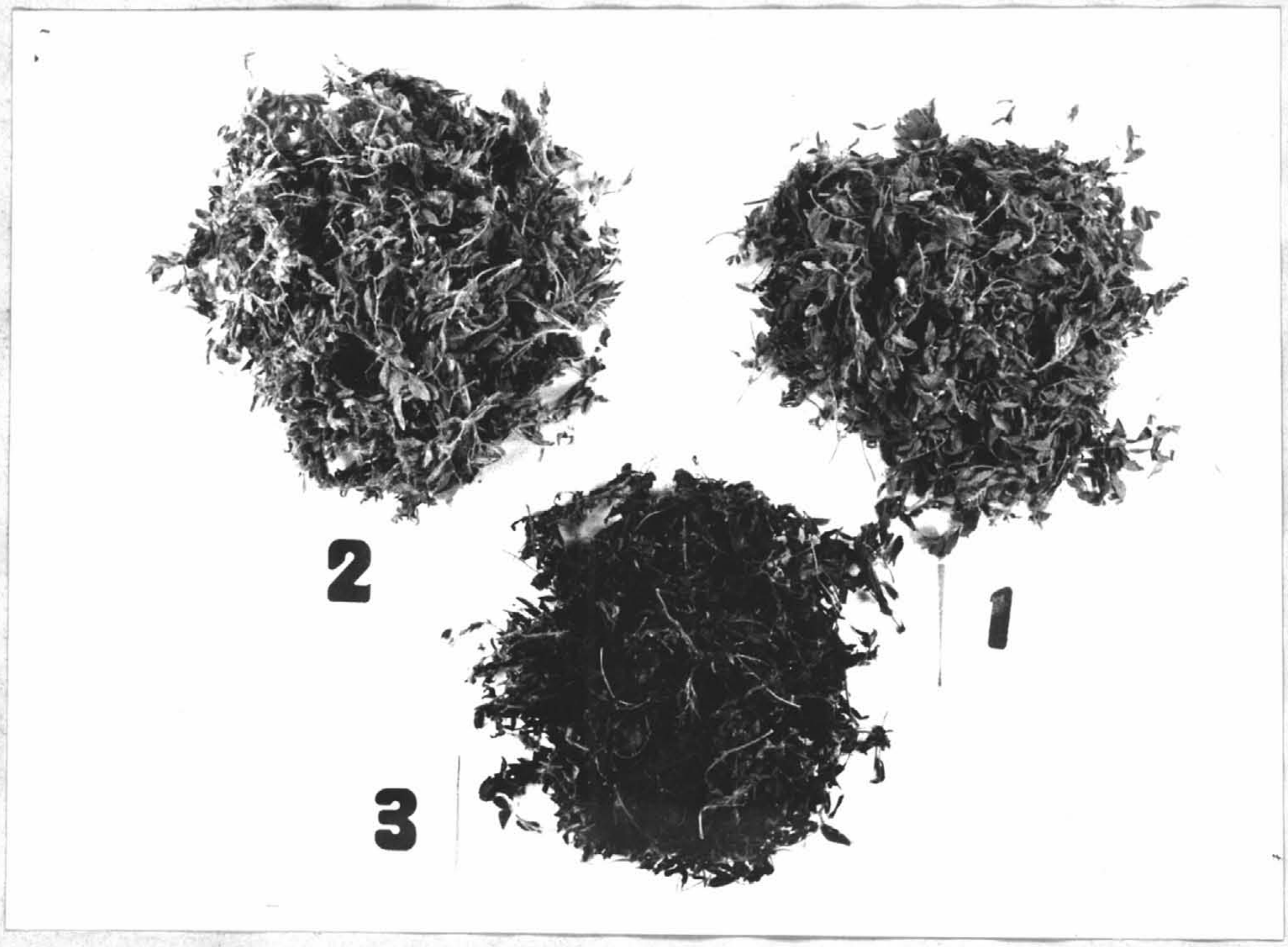
samples which were treated with or without chemicals and control samples. However, there were much less losses observed in samples which were treated in 2.0 per cent NaCl + 0.2 per cent KMS solution than in those samples treated with other set of chemicals and no chemicals blanching.

At the end of three month's storage also a similar trend in chlorophyll losses was observed in both the methods of drying. The chlorophyll losses further increased in all the treatments and it was maximum in control sample followed by no chemical blanching. The combination of NaCl and KMS proved to be superior than the other set of chemicals in both the methods of drying. At the end of third month's storage the A_2B_2 treatment restricted the loss to 45.14 per cent in sun-drying as against 39.11 per cent in cabinet-drying.

As regards the method of drying all the cabinet-dried samples retained more chlorophyll than the sun-dried products which is quite evident from plate III. A blanched cabinet-dried sample with 2.0 per cent NaCl + 0.2 per cent KMS lost, 27.17 per cent, 34.03 per cent and 39.11 per cent of chlorophyll as against 30.85, 37.47 and 45.14 per cent in sun-drying at the end of 1st, 2nd and 3rd month's storage respectively.

However, the rate of loss of chlorophyll after drying was more in blanched samples as compared to unblanched control during the first month's storage as can be seen by comparing the values given in Table 7 with the values of Table 8. The loss of chlorophyll immediately after drying was 51.00 per cent in

PLATE III



1. Cabinet-dried control
2. Sun-dried control
3. Blanched sample with 2.0% NaCl + 0.2% KMS
   at 90°C in cabinet-drying

sun-dried control product which further increased upto 59.48 per cent after a month's storage (an increase of 8.48 per cent) whereas, for the same period of storage the loss was more than 8.48 per cent in any of the treated samples. This can be attributed to the heavy losses of chlorophyll during drying in untreated samples and as such there was lesser loss in storage. On the contrary the losses of blanched products were minimum during processing and drying but they increased during storage of first month only.

From the above brief account it is very clear that the blanching with chemical preservatives is essential for preserving green colour through out the storage period. The results are in close agreement with those reported by Bhatia et al.(1963) who maintained that the chemical preservatives are necessary during blanching for preserving chlorophyll during storage. Jafer (1966) reported that blanching of the okra with NaCl solution helped in maintaining the green colour of the fruit, while Sistnenk et al. (1970) concluded that blanching treatment helped in colour retention of summer squash puree. Similar results were obtained by Patil (1976) working with fenugreek leaves.

4.2.5.2 Effect on ascorbic acid :

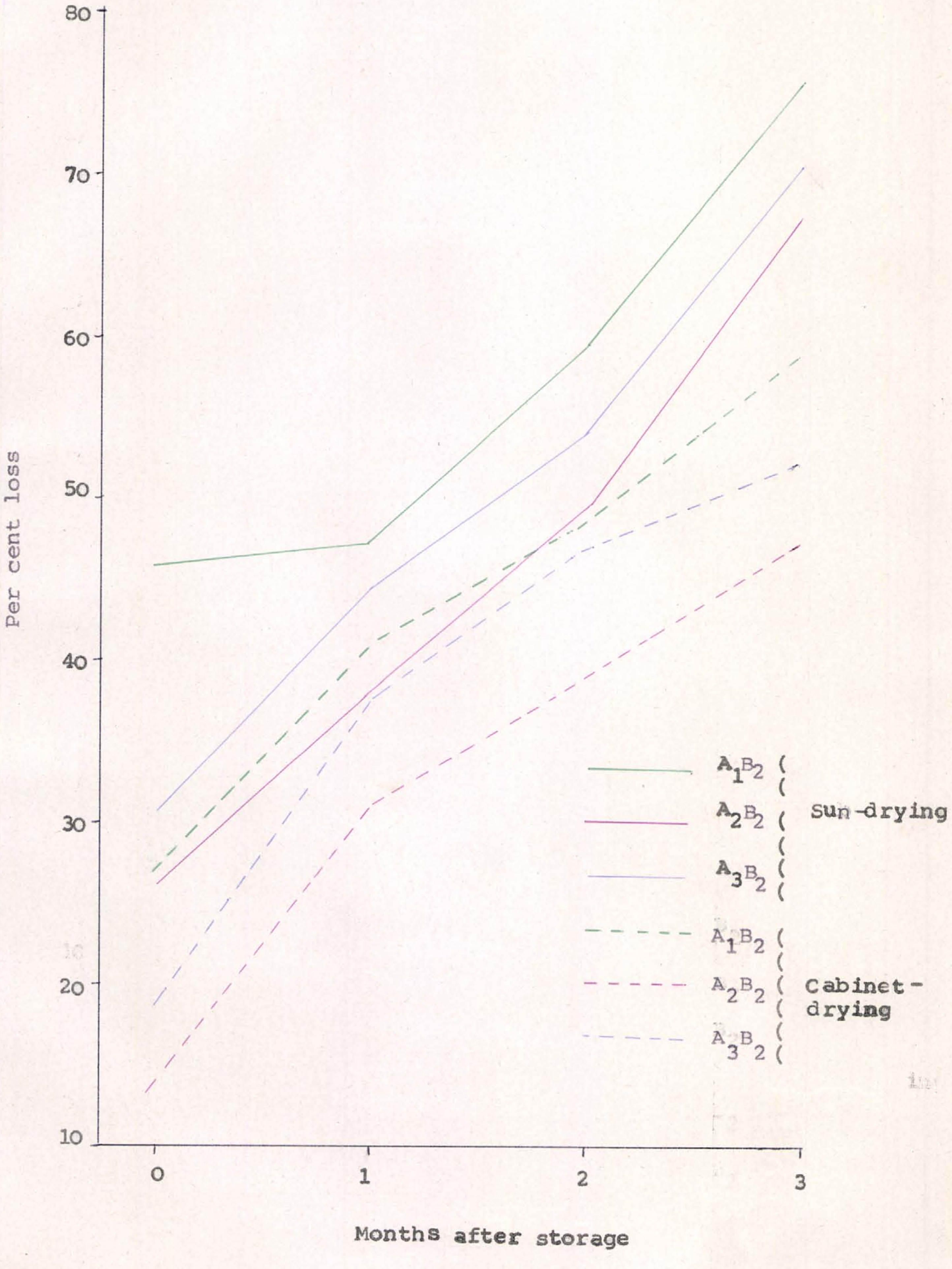
A perusal of the data in Table 9 reveal that there was a maximum loss of ascorbic acid in unblanched samples in both methods of drying as compared to blanched samples with or without chemicals. The sun-dried control product lost its ascorbic acid upto 81.13 per cent as against 38.08 per cent in a sample blanched by HTST method with 2.0 per cent NaCl + 0.2 per cent KMS at the end of a month's storage. There was steady reduction in the loss of ascorbic acid from unblanched to the blanched samples, with or without chemical blanching.

Table 9 : Data regarding the per cent loss of ascorbic acid of gram leaves in sun-dried and cabinet-dried products during storage at room temperature (Values calculated on dry weight basis)

Treatment Symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet-dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	81.13	90.24	98.06	74.78	81.60	96.21
A_1B_0	73.21	83.68	90.51	64.12	71.98	81.23
A_1B_1	66.98	76.96	84.27	54.97	66.42	76.34
A_1B_2	47.25	59.27	75.28	40.99	48.96	59.12
A_2B_0	56.13	75.22	84.76	46.87	55.16	64.46
A_2B_1	50.12	63.00	75.94	43.31	48.14	55.11
A_2B_2	38.08	49.69	67.14	31.10	39.03	47.03
A_3B_0	65.94	78.70	87.03	58.14	65.22	70.38
A_3B_1	60.41	72.67	80.22	45.00	60.19	61.31
A_3B_2	44.68	54.05	71.24	37.48	46.99	52.10

As regards the time-temperature range the high-temperature short-time method proved to be superior than the MTMT and LTLT methods in sun-drying as well as cabinet-drying. Among the various chemical combinations the set of 2.0 per cent NaCl + 0.2 per cent KMS proved better than the

Fig. 7 : Loss of ascorbic acid in sun- and cabinet-dried gram leaves after drying and storage for three months



KMS, MgO and $NaHCO_3$ combination. The A_2B_2 treatment lost only 38.08 per cent of ascorbic acid as against 44.68 in the A_3B_2 treatment and 47.27 per cent in A_1B_2 treatment at the end of one month's storage in sun-drying method. A similar trend of chemical effect was observed in cabinet-drying also.

At the end of second month's storage also the trend remained the same under both the methods of drying. There were further losses of ascorbic acid in all treatments. However, there were much less losses of ascorbic acid found in chemically treated samples than the water blanched samples and control sample.

The loss of ascorbic acid further increased at the end of third month's storage in all the treatments and for both the methods of drying. Even then the treated samples in both the methods retained maximum amount of vitamin C than the other water blanched and unblanched samples. The minimum losses were observed in A_2B_2 treatment viz. 67.14 per cent and 47.03 per cent as against 98.06 per cent and 96.2 per cent in control of sun-dried and cabinet-dried products respectively, thus indicating that the chemical preservatives are much helpful for minimising the losses of ascorbic acid.

As regards the method of drying all the cabinet-dried samples retained more ascorbic acid than the sun-dried samples under the same set of treatments. A blanched cabinet-dried product with 2.0 per cent NaCl + 0.2 per cent KMS restricted the loss to 47.03 per cent as against 67.14 per cent in sun-drying after 3 month's storage period. So it is very clear that the cabinet-drying method is far better than the sun-drying method for preserving vitamin C.

Eventhough the blanching helps in retaining more ascorbic acid during processing and storage, the rate of loss is more in blanched product with or without chemical during the first month of storage ~~content~~. This is due to the lowest ascorbic acid in control product after drying, which automatically decreased the rate of further loss during storage, while the blanched samples with or without chemical treatment retained more ascorbic acid during processing and subsequent drying and the rate of loss increased during first month's storage, eventhough, it was lesser than the total loss produced by unblanched samples during the same storage period.

The above findings are in close agreement with those reported by Eheart *et al*. (1945), Morgan *et al*. (1945), Singh (1972) and Patil (1976). Eheart (1945) reported that blanching is a must for retaining maximum ascorbic acid while Morgan(1945) reported that blanched samples of spinach lost less ascorbic acid than unblanched ones during storage. According to Singh (1972) KMS is essential for retaining ascorbic acid during storage. He has recommended 0.3 per cent KMS in blanching water. Patil (1976) concluded that slow drying causes more loss of vitamin C during storage of fenugreek vegetable than that of oven-dried samples.

4.2.5.3 Effect on beta carotene :

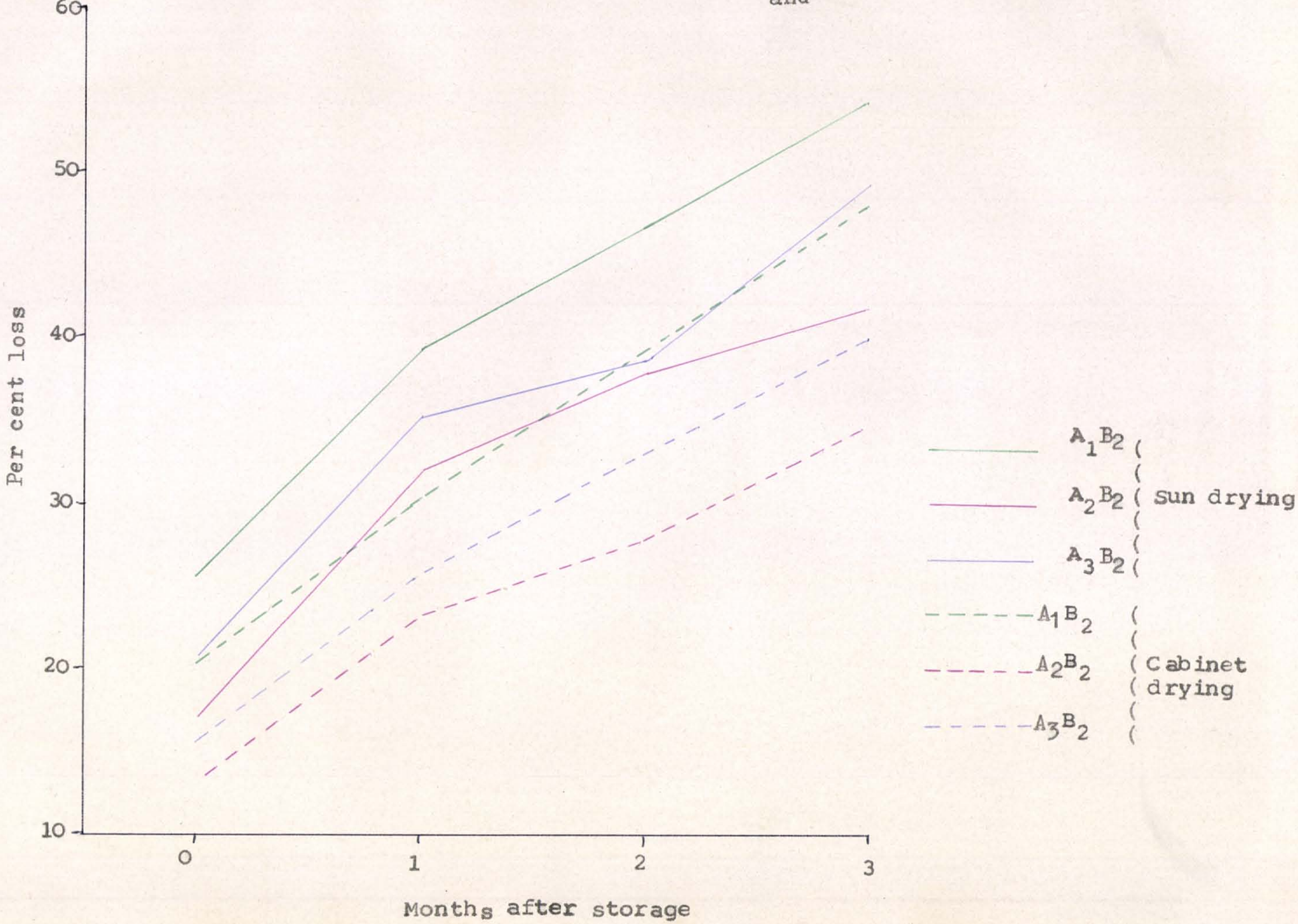
The data presented in Table 10 reveal that the blanching is helpful in retaining more beta carotene during storage as was the case with chlorophyll and ascorbic acid. During storage, the blanched samples with or without chemical treatment retained appreciably more amount of beta carotene than the unblanched control samples in both the methods of drying.

Table 10 : Per cent losses of beta carotene of gram leaves during storage, in sun-dried and cabinet-dried products (Values calculated on dry weight basis).

Treatment symbol	Per cent loss in sun-dried product after			Per cent loss in cabinet-dried product after		
	One month	Two months	Three months	One month	Two months	Three months
A_0	57.33	62.40	68.53	49.10	56.62	60.10
A_1B_0	47.06	54.90	62.84	42.17	50.11	55.22
A_1B_1	41.40	49.46	55.59	34.67	44.10	50.31
A_1B_2	39.43	46.94	54.48	30.17	39.32	47.83
A_2B_0	41.54	47.09	51.01	36.26	41.39	47.25
A_2B_1	36.19	38.60	44.56	31.23	36.89	42.50
A_2B_2	32.02	37.96	42.00	22.94	27.97	34.61
A_3B_0	42.14	45.91	54.09	37.41	42.12	49.19
A_3B_1	41.05	41.05	50.88	33.55	40.20	46.02
A_3B_2	35.17	38.70	49.12	25.52	33.06	40.06

As regards the time-temperature combination the high-temperature short-time method is quite superior over the medium

Fig. 8 : Loss of beta carotene in sun- and cabinet-dried gram leaves after drying and storage for three months



temperature medium time and low-temperature long-time regimes. Similarly the chemical combination of 2.0 per cent NaCl + 0.2 per cent KMS proved to be better than the set of other three chemicals and no chemical blanching. The treatment which was blanched with 2.0 per cent NaCl + 0.2 per cent KMS (A_2B_2) lost 32.02 per cent of beta carotene as against 35.14 per cent loss in A_3B_2 and 39.43 per cent less in A_1B_2 during the storage period of first month in sun-dried product.

Similar trend of reduction in loss of beta carotene was observed in all the treatments under sun-drying as well as cabinet drying at the end of 2nd month. But the amount retained by each treatment was different. The product blanched with NaCl and KMS combination retained maximum amount of beta carotene than that of other set of chemicals and no chemical blanching.

At the end of three month's storage also a similar trend in beta carotene loss was observed in the treatment under sun-drying as well as cabinet-drying. The carotenoid losses further increased in all the treatments of blanching with or without chemical but the treatment of blanching with NaCl and KMS at 90° ± 1°C temperature for two minutes had the minimum loss of beta carotene viz. 42.00 per cent and 34.61 per cent in sun-drying and cabinet-drying respectively. The above treatment combination was followed by A_3B_2 treatment and A_1B_2 treatment in that order in retaining more beta carotene.

As regards the method of drying there was considerable decrease in loss of beta carotene in cabinet dried product as against sun-dried product under the same set of treatments. A blanched cabinet-dried product with NaCl + KMS (A_2B_2) lost 34.61 per cent of its ascorbic acid as against 42.00 per cent in sun-drying at the end of three month's storage. The same trend of reduction in loss of beta carotene was observed in other treatment combinations also.

In respect of the rate of carotene loss observed in storage of blanched as well as unblanched samples as seen from Table 7 and Table 10 it is clear that the rate in unblanched sample was low as compared to blanched ones during the 1st month's storage. This is because of low carotene content in unblanched product after drying due to which the further storage loss was reduced.

The results obtained in respect of beta carotene are in agreement with those obtained by Thelma (1944) who stated that during home drying, beet lost 18.30 per cent of its carotene and during storage the loss went upto 60 per cent. Morgan(1944) reported that there was loss of carotene during dehydration of unblanched spinach and mustard green but when the samples were blanched the loss was effectively controlled. Feinberg (1973) reported that blanching helped in reducing the losses during storage. When the carrot was blanched with sulphite solution, it lost 77.2 per cent of carotene as against 81.9 per cent in only blanching with water and 93.0 per cent in unblanched sample.

4.2.6 <u>Rehydration ratio of gram</u> :

The rehydration ratio of dried gram leaves was worked out in the same way as in spinach and the data so collected are given in Table 11.

Table 11 : Rehydration ratio of gram leaves

Treatment	Sun-dried product	Cabinet-dried product
A_0	4.50	5.30
A_1B_0	3.40	3.45
A_1B_1	3.21	3.20
A_1B_2	3.45	3.50
A_2B_0	3.73	3.90
A_2B_1	4.30	4.25
A_2B_2	4.70	5.60
A_3B_0	3.77	4.10
A_3B_1	4.38	4.40
A_3B_2	4.65	5.50

The data reveal that the treatment in which the blanching was done at 70°C ± 1°C and 80°C ± 1°C temperature with or without chemicals absorbed less water than that of unblanched control product in both the methods of drying. This indicates that the LTLT and MTMT methods of processing are not helpful in increasing the rehydration ratio.

As regards the use of chemical preservatives for increasing the water absorbing capacity there was no appreciable difference between the two sets of chemicals and blanching solution. However, the 2.0 per cent NaCl + 0.2 per cent KMS combination absorbed more water than that of the other set of chemicals in both the methods. Samples treated with both the sets of chemicals absorbed more water than that of water blanched samples. The samples blanched with both the sets of chemicals at 90° ± 1°C absorbed more water than that of control sample thus indicating that the HTST method only is effective in increasing the rehydration ratio.

About the effect of drying methods on rehydration capacity it was observed that there was considerable different in sun-drying and cabinet-drying. The cabinet-dried sample absorbed more water than the sun-dried one. In almost all the treatments the ratio in control sample of sun-drying method was 4.50 as against 5.30 in cabinet-dried sample. The treatment A_2B_2 which was blanched at 90° ± 1°C temperature for two minutes gave the maximum ratio of 5.60 in cabinet-drying as against 4.70 in sun-drying.

The data presented in Table 11 fairly agree with those reported by Teotia and Awasti (1968) and Patil (1976). Teotia and Awasti stated that treatment to jack fruit bulb during blanching improved the rehydration ratio while Patil (1976) reported that the cabinet-drying method gave maximum rehydration yield when the samples were blanched with KMS, MgO and $NaHCO_3$.

4.2.7 <u>Culinary quality of the product</u> :

The culinary quality of the product was observed by a panel of five judges in respect of colour, texture, flavour, appearance and taste of prepared gram leaves vegetable. The data on the scores of different treatments products are presented in Table 12.

Table 12 : Culinary quality of sun-dried and cabinet-dried products of gram vegetable

Treatment symbol	Sun-dried product						Cabinet-dried product					
	Colour (15)	Texture (15)	Flavour (15)	Appearance (15)	Taste (40)	Total (100)	Colour (15)	Texture (15)	Flavour (15)	Appearance (15)	Taste (40)	Total (100)
A_0	4	5	5	5	20	39	6	6	7	7	23	49
A_1B_0	5	5	6	5	24	45	6	7	9	8	27	57
A_1B_1	6	7	8	7	24	52	8	8	9	9	28	62
A_1B_2	6	7	7	7	23	50	7	7	10	9	28	61
A_2B_0	7	8	10	8	25	58	11	9	13	11	28	72
A_2B_1	7	9	12	8	29	65	11	10	13	10	29	72
A_2B_2	8	11	12	8	30	69	10	12	13	11	33	79
A_3B_0	6	8	11	7	26	58	10	10	12	9	29	70
A_3B_1	7	9	10	8	26	60	9	11	12	10	30	69
A_3B_2	7	8	10	8	27	60	9	11	13	10	30	73

The data in Table 12 give clear idea that the various organoleptic test parameters of products scored differently. The blanched samples with or without chemical secured more marks than the unblanched control product in both the methods of drying. The unblanched product secured less marks in every test parameters. The colour of control product was very faint due to which the appearance of prepared vegetable was also unattractive.

The blanched samples with any set of chemicals secured more marks than the tap water blanched samples and control ones in both the methods of drying. Among the sets of chemicals used, the combination of NaCl and KMS scored the highest marks followed by the other set of three chemicals in each aspect of test. There was not much different observed in samples blanched at different temperatures. However, very small different was observed between the three i.e. LTLT, MTMT and HTST methods of processing. The HTST method secured higher number of marks than the other two methods.

There was considerable difference observed in sun-dried and cabinet-dried products in respect of colour, flavour, appearance and taste. All the cabinet-dried products including the control secured more marks than the sun-dried products under the same set of treatments. The cabinet-dried product had dark green colour and thus had good appearance, whereas, the sun-dried products, were pale yellow in colour after cooling as they had lost most of their chlorophyll during storage of three months. The treatment A_2B_2 was found to be the best one in respect of colour, texture, flavour and taste of the finished product, securing maximum marks viz. 69 and 79 for sun-dried and cabinet-dried products respectively.

4.3 Comparative response of spinach and green leaves to various treatments

The present study was undertaken simultaneously for spinach leaves as well as gram plant tops. It will be seen from the data presented in Tables 1 and 7 that spinach and gram responded differently to some of the treatments along with their response to most of the treatments was the same viz. both gave better products when blanched as compared to unblanched ones. Similarly HTST method proved to be superior to MTMT and LTLT methods of processing in reducing the losses of chlorophyll, ascorbic acid and beta carotene, the essential constituents. Both produced better quality products when dried in cabinet-drier than in the sun.

But the boiling temperature (HTST) which proved to be superior for spinach proved to be too high for gram. Boiling temperature produced pulpy mass of gram leaves and as such 90°C proved to be optimum high for gram leaves. This could be attributed to the lender tips of the gram plant tops and the maleic acid which is present in it.

Similarly, the chemical combination of KMS, MgO and $NaHCO_3$, which proved superior in reducing losses of chlorophyll ascorbic acid and beta carotene in spinach, proved inferior to NaCl + KMS combination for the same purpose in grams. This could be due to the interaction between the maleic acid of gram leaves with $NaHCO_3$ or MgO or both which rendered the second set of chemicals ineffective for grams. There are no published data available to support this assumption.

Similarly, the drying as well as rehydration ratios in gram leaves (Tables 7 and 11) were much higher than the corresponding ratios of spinach (Tables 1 and 5). This can be attributed to the sussulancy of the spinach leaves and comparatively dry gram plant tops which contain a part of the stem also. The rehydration ratio in gram was also higher. This could be due to fact that the dried stems absorb more water than the leaves due to their anatomical differences.

CHAPTER IV

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was carried out during the period between February, 1979 to June 1979. Summary of the work done and conclusions drawn as a result of this investigation are presented below.

5.1 Spinach :

5.1.1 Blanching :

All blanched samples in both the methods of drying viz. sun-drying and cabinet-drying retained more amount of chlorophyll, ascorbic acid and beta carotene than that of control (unblanched) samples after drying and during subsequent storage. All blanched samples with or without chemicals resulted in lower drying ratio than that of untreated control samples. Their culinary quality was also adjudged to be better than unblanched products after storage.

5.1.2 Time-temperature combination :

The high-temperature short-time method (HTST) of blanching controlled the losses of all three major constituents viz. chlorophyll, ascorbic acid and beta carotene very effectively than the medium-temperature, medium-time (MTMT) and low-temperature long-time (LTLT) methods of blanching in both the methods of drying after drying and during subsequent storage.

5.1.3 Effect of chemicals in blanching liquid :

All chemically treated samples either with 2.0 per cent NaCl + 0.2 per cent KMS or with 0.5 per cent KMS + 0.1 per cent

MgO + 0.1 per cent $NaHCO_3$ retained more amount of chlorophyll, ascorbic acid and beta carotene during drying and storage for three months than the blanched samples without chemicals and the unblanched control. Between the chemical sets used, the KMS-MgO-$NaHCO_3$ combination was found to be superior to the set of two chemicals viz. NaCl and KMS in both sun-drying as well as cabinet-drying.

5.1.4. Methods of drying :

Between the two methods of drying viz. sun-drying and cabinet-drying employed during the present investigation, it was observed that the cabinet-drying method was superior over the sun-drying method in every respect. All the cabinet-dried products including control sample retained more chlorophyll, ascorbic acid and beta carotene than the corresponding sun-dried samples. The drying ratio was higher in cabinet-drying than in sun-drying in each set of treatments. The water absorbing capacity of cabinet-dried product was found to be more than the corresponding sun-dried product. In the culinary quality tests also the cabinet-dried samples proved superior to the sun-dried ones in respect of colour, flavour, appearance, taste and texture.

On the basis of these observations the following broad conclusions can be drawn. The cabinet-dried product which was blanched at boiling temperature for 2 minutes with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ was the best one among all the cabinet-dried and sun-dried products in respect of the maximum retention of chlorophyll, ascorbic acid and beta carotene content. It also produced the maximum rehydration ratio. This was followed by the method of blanching with the second set of chemicals and the blanching without chemicals in that order.

5.2 Gram leaves :

5.2.1 Blanching :

All blanched samples in both the methods of drying viz. sun-drying and cabinet-drying retained more amount of chlorophyll, ascorbic acid and beta carotene than that of control (unblanched) samples after drying and during subsequent storage. All blanched samples with or without chemicals resulted in lower drying ratio than that of untreated control samples. Their culinary quality was also adjudged to be better than unblanched product after storage.

5.2.2. Time-temperature combination :

The high-temperature short-time method (HTST) of blanching controlled the losses of all three major constituents viz. chlorophyll, ascorbic acid and beta carotene very effectively than the medium-temperature medium-time (MTMT) and low-temperature long-time (LTLT) methods of blanching in both the methods of drying, both after drying and during subsequent storage.

5.2.3 Effect of chemicals in blanching liquid :

All chemically treated samples either with 2.0 per cent NaCl + 0.2 per cent KMS or with 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ retained more amount of chlorophyll, ascorbic acid and beta carotene during drying and storage for three months than the blanched samples without chemicals and the unblanched control. Between the chemical sets the NaCl + KMS combination was superior to the set of three chemicals viz. KMS + MgO + $NaHCO_3$ in both sun-drying as well as cabinet-drying methods.

5.2.4 Methods of drying :

Between the two methods of drying viz. sun-drying and cabinet-drying employed during the present investigation, it was observed that the cabinet-drying method was superior over sun-drying method in every respect. All the cabinet-dried products including control sample retained more chlorophyll, ascorbic acid and beta carotene than the corresponding sun-dried samples. The drying ratio was higher in cabinet-drying than in sun-drying in each set of treatments. The water absorbing capacity of cabinet-dried product was found to be more than the corresponding sun-dried products. In the culinary quality test also the cabinet-dried samples proved superior to the sun-dried ones in respect of colour, flavour, textures, appearance and taste.

On the basis of these observations, the following broad conclusions can be drawn.

The cabinet-dried product which was blanched at 90° ± 1°C temperature for 2 minutes with 2.0 per cent NaCl + 0.2 per cent KMS was the best one among all the cabinet-dried and sun-dried products in respect of the maximum retention of chlorophyll, ascorbic acid and beta carotene content. It also produced the maximum rehydration yield. This was followed by the method of blanching with the second set of chemicals viz. 0.5 per cent KMS + 0.1 per cent MgO + 0.1 per cent $NaHCO_3$ and blanching without chemicals in that order.

On the basis of the results obtained in the entire study, it was observed that spinach and gram leaves responded differently to different treatments. Although both required HTST method of blanching for maximum retention of important constituents like chlorophyll, ascorbic acid and beta carotene, the spinach required boiling temperature while gram leaves required 90°C temperature only. Similarly spinach responded better to the set of three chemicals viz. KMS, MgO and $NaHCO_3$ whereas gram leaves did well to retain all these three constituents with only two chemicals viz. 0.2 per cent NaCl + 0.2 per cent KMS.

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APPENDIX

Room temperature during the storage period
(Weekly average)

Week	Maximum °C	Minimum°C
February, 1979		
1st week	30.7	11.6
2nd week	31.3	12.4
3rd week	31.5	10.4
4th week	31.2	15.3
March, 1979		
1st week	32.2	13.3
2nd week	35.6	15.1
3rd week	36.5	14.8
4th week	37.4	16.1
April, 1979		
1st week	37.3	18.5
2nd week	39.3	19.1
3rd week	39.2	19.6
4th week	40.5	20.5
May, 1979		
1st week	39.9	20.1
2nd week	41.1	23.8
3rd week	37.1	21.7
4th week	38.0	21.4
June, 1979		
1st week	38.6	23.6
2nd week	40.9	24.5
3rd week	38.0	23.4
4th week	35.5	24.6
5th week	30.7	22.8

APPENDIX II

Chlorophyll , ascorbicacid and beta carotene content of fresh spinach and gram leaves.

(Values calculated on fresh weight basis.)

	Chlorophyll	Ascorbicacid	Beta -carotene
Spinach	1.938 mg/lit.	22.95 mg/100g	12. 0 ppm/100g
Gram.	3.129 mg/lit.	57.89 mg/100g	22.00ppm/100g