STANDARDISATION OF TECHNIQUES FOR RETENTION OF GREEN COLOUR IN PROCESSED PEPPER (*Piper nigrum*, Linn.)

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Standardisation of techniques for retention of green colour in processed pepper (*Piper nigrum*, Linn.)" is a bonafide record of research work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
27th December, 1984.

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CERTIFICATE

Certified that this thesis, entitled "Standardisation of techniques for retention of green colour in processed pepper (*Piper nigrum*, Linn.)" is a record of research work done independently by Shri Thomas, K.G. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Spices play a vital role in world trade due to their varied properties and uses. India, with its favourable climatic and soil conditions for growing spices and other semi-tropical herbs enjoys an enviable position as world's major producer and exporter of spices. The glorious past history of the spice industry has been described by Parry (1953).

Pepper (*Piper nigrum*, Linn.) is by far the most important spice of the world accounting for about 35 per cent of the total world trade in spices. Its supremacy remains unchallenged (ASTA, 1964). India, which once contributed for 80 per cent of the global trade in pepper, now accounts only for 20 per cent. Other major producing countries of pepper are Brazil, Malaysia (Sarawak) and Indonesia.

The vast bulk of pepper traded internationally is in the black and white forms. These products are further processed into powders and extracts such as oils and oleoresins. The major defects of powdered spices are the presence of thermo-resistant bacterial load, non-uniformity of flavour and strength and the loss of quality during storage compared to natural spice (Pruthi, 1980). A sizeable quantity of pepper oil and oleoresin is being exported from India since early seventies. At present, the growth rate for these commodities appears to have levelled off to a certain extent, which calls for immediate steps to find out new forms and other uses (Nair and Devakaran, 1981).

Recently Germany, France and other European countries prefer to obtain pepper in its natural form possessing attractive green colour and aroma so as to serve them with special meat dishes. This aptitude created a growing demand for green pepper in canned and pickled forms. As not much of control over the selection of the raw material is exercised,, these products now exported are not of uniform quality (Lewis, 1981). High cost of packing and freight charges are other problems encountered. Research at the Central Food Technological Research Institute (CFTRI) has led to the development of a noval product, namely, dehydrated green pepper. This product is being exported from India since 1976 in a very limited quantity(Mathew, 1978 a).

Green pepper products are still considered a luxury item and hence have only limited market at present, the total world trade amounting to only about 2,000 MT a year. These are used in the catering sector for garnishing steaks and other specialised preparations. The major producing and exporting countries are Brazil, Madagascar and India. During 1983-84, 100 MT of dehydrated green pepper was exported from India which earned a foreign exchange of Rs.46.3 lakhs. In view of its spicy flavour like freshly harvested produce, further improvement in its colour retention and other quality factors is necessary as its use is bound to increase in years to come.

Lewis et al. (1976) found that the technique presently available is not so successful for processing berries of certain light coloured cultivars such as Uthirankotta, Balankotta and Panniyoor-I which are also some of the important ones.

Therefore, it is necessary to assess the attributes of Karimunda as well as Panniyoor-I to explore the possibilities of improving the already available technique for processing dehydrated green pepper. Hence, studies were undertaken at the College of Horticulture, Vellanikkara during 1983-84 with the following objectives:

(I) To standardise techniques to retain green colour in processed pepper.

(ii) To assess the accumulation pattern of chemical constituents in pepper berries of different maturity stages.

(iii) To study the extent of retention of chemical constituents in the processed material.

(iv) To find out optimal storage conditions for the processed produce and

(v) To work out the economics of processing techniques.

REVIEW OF LITERATURE

REVIEW OF LITERATURE.

Pepper, the most important spice earns valuable foreign exchange to the tune of 300 to 400 million rupees annually to India. Due to heavy competition in the world market for black pepper, diversification in export commodities suiting to international demand is necessary. According to George and Velappan (1981), our pepper production is expected to go up in the near future leading to surplus for processing and further export. Of late, there is a growing demand from European countries, Japan and U.S.A. for processed green pepper possessing quality attributes of fresh green pepper. Local industries also demand for newer scientific techniques and quality standards (Lewis,1981).

Literature on product diversification in pepper is rather scanty. A review of the work done so far in this field is presented in this chapter.

2.1. Chemical Composition

In plants, chemical constituents are not homogeneously distributed. Detailed understanding of the distribution of chemical constituents in plant tissues have helped in devising methods for processing and protecting the constituents of economic and commercial values.

Mangalakumari (1983) found that histochemical changes occurred in pepper berries as a result of fertilization. Important post-fertilization changes reported were biosynthesis and deposition of chemical constituents like essential oil, piperine, starch and flavanols.

Data on chemical analysis of pepper have been reported by Jacob (1951) and Dwarakanath et al. (1959; 1961 and 1963). Physio-chemical characteristics of 82 samples of different grades of black pepper have been discussed by Malik and Battacharya (1965). Pruthi (1968), has also reviewed the work done on the physio-chemical characters presenting the range of variation of each constituent. Jose and Nambiar (1972 a and 1972 b), and Pruthi et al. (1976) have reported the proximate analysis of black pepper samples of different cultivars of India. The main constituents generally analysed were moisture, volatile oil, non volatile ether extract (NVEE), alcohol extract, ash, crude fibre, starch, crude protein and crude piperine. According to Mathew (1978), the proximate percentage composition of black pepper was moisture 10 to 12, volatile oil 2 to 4, piperine 4.7 to 5.9, non-volatile ether extract 6.4 to 11.5, crude fibre 10.3 to 18.3, starch 22 to 48 and ash 5 to 6. Although the major constituents of pepper are starch, fibre and fat, the pungent principles and aromatic essential oil are of significance from quality point of view.

2.1.1. Pungent principles

Guenther (1952) and Gillman (1957) described chavicine as the most important pungent component in black pepper. According to Nambudiri et al. (1970), the pungency in black pepper known as 'bite' was attributed to alkaloids belonging to the piperidine group. Of this piperin form was found to be 90 to 95 per cent. Jose (1973) described the relationship between pungency and structural configurations of the compounds. Verzele et al. (1979) established that piperine was the best pungent principle if it could be made available in pure form and all other isomers have little taste. According to Sumathikutty et al. (1981), the piperine content in pepper gave the measure of the pungency which ranged from 2 to 6 per cent in pepper cultivars. However, there were many reports about isolation of minor alkaloids such as piperettine, piperanine, piperylin etc. apart from the isomer chavicine.

Only scattered reports are available on the piperine content of pepper cultivars of Kerala (Dwarakanath et al., 1958; 1963; Lewis et al., 1969 a and Jose and Nambiar, 1972 a); cultivars of different regions of India (Dwarakanath et al.,1961) and of different trade grades and byproducts of pepper (Dwarakanath et al., 1959 and Sumathikutty et al.,1979).

Lewis et al. (1969 a) noticed that the constituent piperine was concentrated towards the endosperm of pepper berries. Mangalakumari (1983) found that piperine was located in oval shaped and thin walled cells present in the inner core of the pepper berries. Further, in pin-head stage, the piperine cells were absent. When the skin and inner core of the mature berries were separated and piperine estimated, the inner core was found to contain 83 and skin seven per cent. But piperine could not be located histochemically in the skin.

According to Janot and Chaignean (1947), piperine sublimed at 104 ^{o}C at 0.02 mm pressure. Chinova et al.(1969) found that piperine was stable both quantitatively and qualitatively even after six months preservation in paper. Aluminium tin lined paper helped its preservation even upto 10 months. Sumathikutty et al. (1981) have reported piperine as insoluble in water, sparsely soluble in alcohol and highly soluble in chloroform, ether, benzene and acetic acid.

2.1.2. Aroma constituents

The aroma and flavour of pepper are determined by the composition of steam volatile oil contained in it. The composition of black pepper oil was first reported by Dumas (1835). Suberaine and Capitaine (1840) found that pepper oil contained a high proportion of monotarpene hydrocarbons and a small proportion of oxygenated compounds. According to Lewis et al. (1969 a), pepper contained three oxygenated compounds. Lewis et al. (1969 b) clearly illustrated the possible extent of difference in oil composition according to raw material used. They have also summarised the reports of earlier workers on the composition of pepper oil. The volatile oil content of some popular cultivars was reported by Nambudiri et al. (1970) and it ranged from 2.4 to 3.5 per cent. Richard et al. (1971) screened the essential oil content of seventeen cultivars of pepper grown in Kerala. Debrawere and Verzele (1975) identified 51 oxygenated compounds in pepper oil. Mathew and Sankarikutty (1977) reported the distribution of hydrocarbons in the oils obtained from some of important cultivars of Kerala.

Lewis (1981) established that different cultivars of pepper gave oils of different aroma quality, consequent to the different proportion of terpenes, sesquiterpenes and oxygenated compound contained in them. Rajaraman et al. (1982) found that pepper oil contained chiefly terpenes and sesquiterpenes and to a small extent some of the oxygenated compounds. These again varied widely between cultivars.

Hardman (1972)reported that the oil cells in pepper berries were located in the inner part of the fruit wall. According to Mangalakumari (1983), the essential oil cells in pepper berries were distributed mainly in the skin and these cells constituted a membraneous layer in the inner core. The essential oil cells were restricted to a very small region in the tip of the berry. Lewis et al. (1969 b) had also referred about a silver skin in pepper berry which probably corresponded to the membraneous layer.

2.1.3. Nonvolatile ether extract (NVEE)

Analysis of black and white pepper of different cultivars showed considerable variation in the NVEE content which ranged from 6 to 12 per cent. (Dwarakanath et al.,1959; Guenther et al.,1969; Jose and Nambiar, 1972 a and Govindarajan, 1977). The major part of NVEE was represented by pepper alkaloids (Jose, 1978).

The earliest method of calculating pungency was through nitrogen estimation in the NVEE, which gave an exaggerated value because of the presence of other nonpungent nitrogenous compounds (ASTA, 1960).

2.1.4. Starch

Mitra et al. (1966) suggested that an estimation of starch in pepper could give an idea about the light pepper content. Lewis (1969 a) indicated that light pepper showed a low starch and high fibre content as the core had most of the starch and less of fibre.

According to Govindarajan (1977), starch was the predominant constituent in black pepper which ranged from 35 to 40 per cent by weight. It was much higher in white and decorticated peppers. The values ranged from 53 to 58 per cent in white pepper and upto 63 per cent in decorticated pepper. Jose (1978) found that starch contributed to 30 to 50 per cent of total weight of dried berries on moisture free basis and it was directly proportional to bulk density (weight/litre). High starch content allowed fine powdering. According to Mangalakumari (1983), starch in pepper berries were seen as aggregates, enclosed in sheaths. She could not locate starch in the unfertilized berries and could find the same in the inner core after fertilization. At fully mature stage profuse quantity of starch was observed.

2.1.5 Fibre and ash

According to Govindarajan (1977), the fibre and ash content were considerably lower in white pepper because of the removal of outer layers during its preparation. Sumathikutty et al. (1979) reported increase in fibre content until maturity stage. The decrease in the concentration of fibre towards maturity was obviously due to large scale increase contributed significantly by starch. Purseglove et al. (1981 a) indicated that 25 per cent of the dry weight of black pepper was due to the outer skin which consisted mainly of fibres.

2.1.6. Change in constituents corresponding with maturity of berries

According to Poulose (1973 b) and Pruthi (1977), pepper required six to eight months period from flowering to harvest. Purseglove et al. (1981 a) reported that pepper required about six months from flowering to harvest.

Variations in quality factors during the course of development of pepper berries have been studied by few workers (Dwarakanath et al., 1963; Govindarajan, 1976; Pruthi et al., 1976 and Mathew, 1978). They found that pungency decreased corresponding with maturity. Volatile oil also exhibited a falling tendency proportionate to maturity. Starch content increased while moisture and crude fibre decreased with increasing maturity.

Sumathikutty et al. (1979) reported that accumulation of piperine in a berry reached the maximum at about a stage slightly lesser than the normal maturity and afterwards there was no increase. She has observed an increasing trend in starch content and decreasing trend in fibre content with increased grade size which was indicative of the possibility of getting larger grades at higher maturity stages. But active constituents like volatile oil and piperine did not show any pattern of change.

According to Purseglove et al. (1981 a), the volatile oil content of immature pepper berries reached maximum at a relatively earlier stage, about four and a half months after fruit setting in some cultivars in India and then diminished. But the piperine content continued to increase for some more period.

Mathai (1981) found that the steep fall in the concentration of crude fibre during maturity corresponds to a similar rise in starch content. To some extent this might be due to interconvertion of these two constituents. He has also reported that the sudden fall in crude fibre content during the first half was related to an almost rise in oleoresin and piperine contents.

Ratnawatha and Lewis (1983) found that, as the berries became more and more mature, the flavour principles got reduced which was attributed to dilutioning principles due to increase in starch content.

Purseglove et al. (1981 a) could pre-determine the chemical characteristic of pepper berries by exercising control over the time of harvest depending on the variety.

2.1.7. Variation in quality attributes between cultivars

Dwarakanath et al. (1958) and Lewis (1970) assessed the volatile oil and NVEE content of some well known cultivars. It was reported that Kumbhakodi, Kottanadan, Arikotta, Kuthiravally and Arikottanadan possessed about 10 per cent NVEE and they were classified as good varieties for oleoresin extraction. According to Jose and Nambiar (1972 a), Kottanadan and Kuthiravally were superior, while Uthirankotta, Balankotta and Talakodi were low in piperine and volatile oil contents.

Lewis (1973) identified some important pepper cultivars as suitable for oil and oleoresin extractions indicating the contents of volatile oil, NVEE and piperine. He also recorded the composition of pepper oil. Poulose (1973 a) rated Panniyoor-I as medium pungent. Govindarajan et al. (1973) evaluated cultivars like Balankotta, Karimunda, Kuthiravally, Mundi and Panniyoor-I for their quality aspects and found differences in odour quality.

Statistical techniques have been reported (Kahan and Stahl, 1973) to distinguish between Lampong and Sarawak black peppers on the basis of the amount of strontium, barium and calcium present. Similar approach was also reported (Russel and Else, 1973) on the basis of volatile oil composition. Lewis et al. (1976) found variation in quality due to soil and climatic conditions. However, some cultivars gave consistently higher extractives. Lewis (1981) established that different cultivars of pepper possessed different aroma quality and pungency factors. As the ultimate use of pepper is found in flavouring of foods, the choice of a cultivar should depend on the flavour quality of the final product. According to Natarajan (1981), in the recent years the pepper importing countries insist on chemical standards in pepper and its products.

2.2. Post-harvest technology

According to Aiyadurai (1966), the processing steps should ensure proper conservation of quality attributes, keeping the loss to the minimum. Larcher (1967) described the post-harvest handling techniques of black pepper practised in different parts of the world. Shankaracharya and Natarajan (1973) have discussed the problems of post-harvest handling of spices. The importers of pepper attach special significance to appearance apart from quality attributes such as aroma and pungency (Mathew, 1978).

2.2.1. Pre-treatments

According to Larcher (1967), the technique of keeping berries for 48 hours in shade had helped in manual separation of berries and for obtaining highest yields of essential oil and piperine. The boiling water treatment was found to alter the chemical composition of the oil.

2.2.2 Washing

Natarajan and Shankaracharya (1974) found that reduction in microbial load in pepper was related to the efficiency of washing and hence, cleaning under pressure was suggested. According to Ramakrishnan and Ramanathan (1981), the traditional method of cleaning and drying of pepper had inherent defects warranting substantial improvement. They could get better quality produce through mechanisation of the process.

2.2.3. Blanching

Blanching is generally practised in vegetable dehydration chiefly for attaining enzyme inactivation (Gooding, 1956). In the case of turmeric, boiling is essential to reduce drying time and to gelatinize the starch (AMS, 1965). Krishnamurthy et al. (1975) found that by boiling turmeric rhisomes in water, the oleoresin cells got raptured and the pigments became more evenly distributed.

In chillies and ginger, blanching was not found desirable because of the destruction of enzymes responsible for the generation of their respective flavours (Natarajan et al.,1970). In case of chillies, steam treatment for about five minutes gave fast colour to the finished product (Laul et al.,1971).

Thiessen and Scheide (1970) found that organoleptic characters of both black and white peppers as well as their oleoresin content changed at 90 °C. The deterioration became more pronounced with further increase in temperature. The duration of heating and the type of container also influenced the degree of deterioration. Major qualitative changes on heating were noticed in the volatile oil, especially to monoterpene hydrocarbons. Pruthi et al. (1974)

found that 90 per cent of volatile oil got removed in just 30 minutes by distillation and to ensure complete extraction, distillation for an hour was recommended. According to Pruthi et al. (1976), blanching reduced the recovery of both volatile and non volatile ether extract. Lewis et al. (1976) reported that a blanching treatment of pepper berries for about a minute in boiling water gave very dark glossy colour to the dried berries. Prolonged blanching helped to arrest their blackening tendency.

Mangalakumari (1983) found that heating green berries led to increase in the size of the starch aggregates but with no apparent distortion in shape.

2.2.4. Chemical treatments

Chemical treatments are also usually adopted for processing certain spices. But residue left behind by these chemicals should be considered while fixing the optimum dosage. (Natarajan and Shankaracharya, 1974). The ISI specifications (1980) do not allow addition of Sodium metabisulphite more than 1500 mg/kg for dehydrated green pepper. According to Govindarajan (1981), presence of even one ppm of SO_2 in pepper products are not legally allowed in certain countries.

2.2.4.1. Alkali treatments

Boiling in 0.1 per cent sodium carbonate solution is a commercial practice in turmeric processing as it helped proper development of colour (Desikachar et al.,1959). The attractive green colour of cardamom got stabilized to a great extent by steeping it in two per cent sodium carbonate solution for 10 minutes (Natarajan et al.,1968). Alkali treatment has been found to be useful in conjuction with olive oil in drying chillies (Laul et al.,1970).

2.2.4.2. Antioxidant treatments

The attractive red colour of capsicums or chillies is mostly due to Carotenoids which could be stabilised to a great extent by treating with a suitable antioxidant (Lease and Lease, 1956 b).

According to Natarajan et al. (1969), treatments given to whole chillies with BHA (Butylated hydroxy anisole), propyl gallate or ascrobic acid did not show a very significant effect on the preservation of colour of spice on storage.

2.2.4.3. Bleaching

Bleaching powder, sulphur dioxide or hydrogen peroxide are generally used for bleaching cardamom (ICAR, 1967).

Bleaching ginger with lime not only improved the colour but also helped to preserve it better (Rodrigueze, 1971).

2.2.4.4. Canning

According to Pruthi _et al_. (1976), the best technique for preserving and retaining the green colour of bottle preserved pepper was through addition of 100 ppm sulphur dioxide and 0.2 per cent citric acid in 20 per cent brine.

2.2.5. Dehydration

Sun drying though economical, has the disadvantages that it led to contamination and development of non-uniformity in colour and flavour components. Raised platforms or racks, besides enhancing drying rate, reduced contamination (Pruthi, 1980).

Mangalakumari _et al_. (1983) found that during drying green pepper berries, the turgidity of the cells were lost and phenolic extractives spread outwards along with the movement of moisture from inside to outside.

2.2.5.1. Mechanical methods

Pruthi _et al_. (1959) studied the comparative efficiency of different methods of dehydration such as hot-air drying, cross-flow drying, through-flow drying, freeze drying and vaccum shelf drying and compared them with sundrying. They found through-flow dehydration as better from the point of view of economics and retention of quality attributes.

2.2.5.2. Drying temperature

Pruthi et al. (1959) reported that the temperature of air used in dehydration greately influenced not only the time but also the quality of the finished product. They had also reported that the optimum drying temperature and the critical temperature varied with the nature of the product. They have advocated an initial temperature of 54 ^{o}C for three hours, followed by 45 ^{o}C for 30 hours and a final temperature of 54 ^{o}C for three hours, involving a total drying period of 36 hours.

According to Murthy et al. (1968), the critical temperature for dehydration of chillies is 46 ^{o}C. But Kuppuswamy (1974) found this temperature to be too low for economic dehydration as the time involved was 40 to 42 hours. Natarajan and Shankaracharya (1974) observed no appreciable darkening of chillies even at temperature range of 140 - 150 ^{o}F.

Natarajan et al. (1972) found that drying temperature of spices was critical due to loss of quality attributes especially volatile substances at high temperature. In most cases, the temperature advocated was between 50 and 60 °C. They found perceptible darkening of ginger at temperatures above 60 °C. There was no significant difference in colour of samples dried at temperatures between 50 °C and 60 °C. Raina *et al.* (1978) have also confirmed the critical temperature for dehydration of Himachal ginger as 60 °C. Purseglove *et al.* (1981 b) reported that in the case of turmeric, dehydration at 65 °C adopting cross-flow air oven method yielded satisfactory product.

2.2.5.3. Moisture limit for safe storage

Pruthi (1980) found that most of the dehydrated foods are hygroscopic. Chen and Gujmanis (1968) observed that chilli powder stored with moisture content of 9 to 10 per cent retained better colour than samples stored with lower moisture content. Natarajan *et al.* (1969) found that stored chillies with moisture content of 11 to 12.9 per cent gave higher colour values than samples stored with moisture below 9 per cent.

CFTRI (1963) work revealed that in green cardamom moisture level of 12 per cent and above was deleterious because of mould attack and colour reversion.

According to White (1957), pepper should be dried to less than 11 per cent moisture for safe storage. The ISI specifications (1961) allowed a maximum moisture content of 12 per cent in black pepper. The ISI specification (1980) for dehydrated green pepper allowed a maximum moisture content of eight per cent only.

2.3. Chemistry of colour retention

2.3.1. Pigments

According to Caxton (1972), the colour of plant pigments was produced by their power to absorb all other colours from the light falling on them. They reflected what they could not absorb. Purseglove et al. (1981 a and b) reported that the attractive colour of green cardamom and green pepper were due to chlorophyll pigments. According to Leopold and Kriedemann (1981), colour change in fruits on ripening was due to formation of carotenoids or disintegration of chlorophyll pigments.

The colour of red ripe capsicum and paprika is due to a complex mixture of carotenoids, xanthophylls, anthocyonins etc. (Sharma and Seshadri, 1955). Atal et al. (1966) reported the occurence of sesamin in long pepper. Pruthi (1980) opinioned that pink discolouration of ginger on dehydration was due to the presence of leucoanthocyonin. According to Purseglove et al. (1981 b), the yellow orange colour of turmeric was due to non-steam volatile diferuloyal methane derivatives of which curcumin was most important.

2.3.2. Cytokinins

Richmond and Lang (1957) have observed that cytokinis were found to defer senescence in xanthium leaves. According to Woolhouse (1967), the chlorophyll and protein content fell rapidly as senescence developed which could be structurally associated with deterioration of the chloroplast. Singh (1980) found that cytokinins prevented break down of chlorophyll.

2.3.3. Enzymes

According to Mayer and Anderson (1952), the enzyme, Phenolase oxidase was widely distributed in plants which oxidised a large number of phenolic compounds resulting in the formation of characteristic dark coloured compounds. Looney and Patterson (1967) reported that changes in enzyme components were involved in altering pigmentation. The development of characteristic colour and flavour during fermentation of tea and cocoa were found to be due to enzymic oxidation of polyphenols (Mathew and Paripa, 1971). Occurance of phenolase oxidase in fruits and vegetables was reviewed in detail by Vamos - Vigyazo (1981).

According to Purseglove *et al*. (1981 b), during the course of curing of vanilla beans after hydrolysis of glucosides, vanillin and other liberated phenols underwent transformations by the action of oxidising enzymes yielding other aromatic compounds and quinones and eventually, stable pigments. Two enzymatic oxidation systems were identified, peroxidase using hydrogen peroxide and an oxidase using atmospheric oxygen. The oxidase was believed to be responsible for the major oxidative transformation including much of the browning. Some methods of killing beans caused damage to the outer tissue, which in turn accelerated the initial rate of oxidase/atmospheric oxygen reactions.

Mangalakumari *et al*. (1983) reported that blackening of pepper berries on dehydration or maceration was as a result of enzymatic oxidation of phenolic compounds. Unlike most other enzymes which loose their activity at high temperature, this enzyme was found to be peculiar in two respects, viz., (i) optimum activity at high temperature of 73-78 $^{\circ}$C and (ii) heating for 10- 15 minutes in boiling water was necessary for complete inactivation.

2.3.4. Polyphenols

Polyphenols impart colour to fruit walls, besides taking part in a number of colour reactions (Batesmith, 1954). On slicing potato and banana, they became brown due to phenol oxidation and identified sodium metabisulphite as a good phenolase inhibitor (Mathew and Paripa, 1971). In tomatoes, green ones contained higher bound polyphenols which got gradually hydrolysed as ripening proceeded resulting in colour change (Skorikova et al., 1978). A possible partial contribution of enzymatic activity by yeast was indicated in fermentation of tea (Pederson, 1979).

According to Mangalakumari et al. (1983), at young stage of pepper berries, the phenolic compounds were distributed through out. But on maturity, they got confined to the epicarp and mesocarp. The blackening occurring in the drying process of pepper also showed a similar pattern of distribution. The phenols in pepper got enzymatically oxidised and gave rise to black colour when the cells were disturbed by dehydration or maceration. This was found to be similar to the activity of yeast in tea.

2.3.5. Antioxidants

Chen and Gujmanis (1968) indicated that deterioration of colour pigments in dehydrated ground chillies during storage was due to an antioxidative process having kinetics of second order reaction. Pruthi (1969) also reported antioxidative activity during bleaching or degradation of colour on storage in Hungerian paprika.

2.3.6. Sunlight

Krishnamurthy et al. (1975) reported that exposure of spices to sunlight resulted in surface bleaching but the extent of colour loss was not reported. According to Singh (1980), the red light had the longest wavelength ranging between 650 and 760 nm. Blue-violet region was composed of short wavelength ranging between 390 and 430 nm.

According to Leopold and Kriedemann (1981), following exposure to redlight, the cytokinins were subjected to rapid fluctuations. The quality of sunlight had specific effect in the spectral sensitivity of many plant processes. The maximal effectiveness to red light was approximately 560 nm and to blue light 430 nm.

According to Narayanan (1983), chlorophyll was absorbed in the region of 600- 650 nm. He opinioned that drying with filtered light, cutting rediation between 575 and 675 nm may likely to have some positive response in retention of green colour in dehydrated green pepper.

2.3.7. Colour retention techniques

2.3.7.1. Pepper

Pruthi *et al.* (1974) showed that pepper berries dehydrated after steeping in acidified sulfited solution (1 per cent potassium metabisulphite + 0.25 per cent citric acid) yielded good product with many green berries and little dark berries. Steeping overnight in eight per cent hydrogen peroxide bleached the colour of the berries giving a white product on sun drying. Steeping overnight in 12 per cent hydrogen peroxide yielded a still whiter product. But, steeping for five hours in 12 per cent hydrogen peroxide prior to dehydration gave a light green product. Lewis *et al.* (1976) reported that a blanching treatment of the berries for about a minute in boiling water activated the blackening enzyme and the dried product attained a dark gloosy colour. A prolonged treatment in boiling water inactivated the blackening enzyme and black colour could be avoided.

Mathew and Sankarikutty (1977) found that green pepper berries turned brown during drying and afterwards black because of enzymatic exidation of a colourless substrate mostly polyphenol present in the skin. This substrate masked the green colour that was left after drying. They found that for preparing dehydrated green pepper, harvesting had to be done a month earlier than the normal harvesting maturity.

2.3.7.2. Cardamom

The process of colour degradation in cardamom has been studied in detail by many workers. According to Natarajan et al. (1968), during the course of chlorophyll degradation the Mg ions in the chlorophyll molecule get substituted with hydrogen ions donated by organic acids present in the fruit, which disintegrated the pyrrole ring structure leading to an irreversible convertion to pheophyten.

According to Thomas and John (1966), the pigmentation in cardamom could be initially fixed by subjecting the harvested capsules to a sudden temperature rise of about 60 °C for three hours in heated chambers leading to killing of the chloroplast and further arresting of vegetative development. Natarajan et al. (1968) recommended alkali treatment prior to drying. The alkali was found to delay the attacking action of hydrogen ions on the chlorophyll, which resulted in a prolonged stabilisation of green colour. According to Purseglove et al. (1981 b), the fading of green colour in cardamom was due to degradation of chlorophyll which was believed to be in analogous with peas and other vegetables.

2.3.7.3. Turmeric

According to Krishnamurthy et al. (1975), on boiling turmeric rhyzomes, the oleoresin cell raptured and the pigments got more evenly distributed. The keto-enol structure of the pigments rendered them sensitive to colour changes due to pH variations. Therefore, boiling the rhyzomes in an alkali medium resulted in the development of rhyzomes of uniform colour and flavour.

2.3.7.4. Capsicum

Lease and Lease (1956 a) reported that colour retention in red pepper was influenced by the stage of ripeness at harvest. Lease and Lease (1962) again found that with the addition of an antioxidants Viz., BHA (Butylated hydroxy anisol) to the ground pepper, the retention of colour could be improved.

2.3.7.5. Green peas

Blair and Ayres (1962) found that on processing green peas, pH fell to six causing degradation of green colour. By a suitable treatment, when the pH was raised to eight the colour could be preserved well.

2.3.7.6. Onion

Lukes (1959) reported that development of pink discolouration in onion during dehydration was due to a native enzyme reaction with a substance in the juice when the cells were raptured, followed by a non-enzymatic reaction with amino acids. A patented process (Li *et al.*, 1967) developed for the prevention of discolouration in onion consisted of addition of 0.05 to 0.3 per cent cystein and an antioxidant (citric or ascorbic acid) and heating to 160- 190 °F.

2.3.7.7. Green vegetables

In early part of cooking, certain green vegetables like cabbage were found to produce considerable volatile acids, which if not allowed to escape, quickly changed the colour of the produce to olive green and then to dull brown. When the volatile acids were allowed to escape by keeping the vessel open while cooking the colour retention was better indicating that the retention of green colour was better only in an alkaline medium (Meyer and Anderson, 1952).

According to Cruess (1958), blanching spinach at boiling point resulted in loss of green colour due to decomposition of chlorophyll to pheophyten. When blanched at 170 °F, it retained its natural green colour to a remarkable extent, even when subjected to later sterilization at 250 °F.

The assumptions on retention of green colour at lower temperature were that:

(i) the oxygen in the leaves oxidised the chlorophyll at boiling point and did not do so at 170 ^{o}F. The gases being given an opportunity to escape from the tissue at lower temperature, oxidation did not occur during subsequent sterilization. Further, subjecting the spinach leaves to a high vacuum for several minutes under water removed gases from the tissue thereby improving the colour attained.

(ii) blanching at lower temperature, leached considerable acids from the vegetables which led to lesser hydrolysis of chlorophyll to pheophyten and

(iii) at lower temperature, the enzyme chlorophyllase remained active for a few minutes and converted chlorophyll to phyllin which helped to retain its green colour.

2.4.0. Packaging

White (1957) found that after proper cleaning and drying to less than 11 per cent moisture the whole black pepper could be stored satisfactorily in double burlop bags with sealed polythene liners of 300 guage or more thickness. Pruthi et al. (1962) worked out the packaging requirement of various spices such as capsicum, paprika, green cardamom etc. which possessed natural colouring pigments requiring protection from light. Viraktamath et al. (1964) reported that cardamom with an initial moisture content below ten per cent withstood transport and storage when packed in 300 gauge black polythylene lined wooden chests. With regard to the effect of ultraviolet light on the reversion of cardamom colour, it was observed that samples kept in polythene bags other than black showed gradual deterioration, in the blue and yellow region after four months of storage. Samples kept in black film bags packaged in wooden chest were effecient in colour retention.

According to Philip (1969), Cartons were the least expensive unit package for whole spices. Most of the disadvantages could be overcome by coating the inner side with best sealable film such as polyethylene. Aluminium foils were excellent for spices, those needed protection from light. A better package for costly spices was found to be air tight wooden boxes suitably lined. Kumar and Anandaswamy (1974), found that low density polyethylene film had good chemical resistance and low water vapour transmission but was hightly permissible to gas and organic vapours. High density polythene sheets were having better rigidity and barrier properties compared to low density sheets. They also reported that heat and light accelerated deterioration especially with oxygen sensitive products.

According to Pruthi (1980), spices and spice products were highly sensitive to moisture. Loss of volatile and aromatic principles and absorption of foreign odours resulted due to inefficient packaging.

2.5.0. Dehydrated green pepper patented by the Central Food Technological Research Institute. Mysore and released through National Research Development Council, New Delhi.

According to Nambudiri et al. (1978), the varieties suitable for making dehydrated green pepper were those which produce dark green small and uniform berries. The correct maturity for harvesting was fixed as 20 to 30 days before ripening.

Freshly harvested green pepper after destalking were freed from pinheads and light berries and then washed. The cleaned berries were treated in hot water and dried in mechanical driers under controlled conditions.

After proper drying to safe storage level, they were garbled, colour graded and packed in polythene lined bags or tea chests. The green colour of this product was fairly stable. Besides, flavour quality was also maintained.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation on the Standardisation of techniques for retention of green colour in processed pepper (*Piper nigrum*, Linn.) was undertaken at the College of Horticulture, Vellanikkara during the year 1983-84.

The materials utilised and the methodology adopted are narrated hereunder.

3.1 Selection of green pepper berries

3.1.1. Cultivars

Berries of cultivars of Karimunda and Panniyoor-I were used for the investigation.

3.1.2. Vines

Ten regular bearing healthy vines of about 15 years age from each of the cultivar were selected. They were maintained at the state seed Farm, Mannuthy adopting the package of practices recommended by the Kerala Agricultural University.

3.1.3. Selection of berries

Pepper spikes of different stages of maturity were harvested in the morning, destalked carefully without damage to berries and then size graded. For getting uniform berries having maximum density, they were immersed in water contained in a deep vessel. The berries which floated above one half of the volume were rejected and the remaining immersed ones were alone utilised for the studies. The percentage recovery of green berries so obtained from the harvest of each stage of maturity was calculated.

3.2. Period of flowering

Normally, pepper vines take about 1 to 1½ months for completion of flowering. This causes differential period for fruit set, consequently in their maturity also. Therefore, it was not possible to fix the correct dates of maturity of berries. Taking into account this difficulty, a vine was considered, when more than 50 per cent flowering could be observed. Based on this, the period of flowering was fixed as second week of July for Karimunda and fourth week of July for Panniyoor-1 for the particular season of study.

3.3. Harvest stages

The spikes were harvested at different pre-fixed stages of maturity. The different harvest stages fixed are indicated in the Table-1.

Table 1. Harvest stages of Pepper berries.

Harvest stage.	Approximate maturity of berries in months.
(1)	(2)
I	3
II	4
III	5
IV	5½
V	6

Spikes possessing maximum development were alone collected at each harvest.

3.4. Processing treatments

Since the berries harvested at the Ist stage were too immature, they were not subjected to processing treatments. Howevar, they were subjected to bio chemical analysis to study accumulation pattern of various chemical constituent detailed under Section 3.6.

The selected berries of the IInd to Vth stages of harvest of both the cultivars were processed as detailed hereunder.

3.4.1 Cleaning

The berries were first washed thoroughly in running water till all the adhering materials got removed. They were then rinsed twice in distilled water and kept in a woven basket to drain off the excess water.

3.4.2 Kinetin

The berries were treated with kinetin of two concentrations viz. 10 and 20 ppm, by steeping them in the respective solutions for three hours. Dipping the berries in distilled water was considered as control for comparison. The berries so treated were subjected to blanching followed by mechanical dehydration.

3.4.3. Blanching

Distilled water at the rate of one litre per kg of berries was taken in a stainless steel vessel and heated on L.P.G. burner. Magnesium sulphate was added just prior to boiling stage using three concentrations viz. 1, 2.5 and 5 per cent and then the berries were added. The temperature was raised to around 100 °C and then ascorbic acid of two concentrations viz. 0.025 and 0.05 per cent was added. The temperature of the media was maintained steadily at around 100 °C but without boiling for varying periods of time viz 10, 12.5 and 15 minutes.

3.4.4. Sulphite treatment

The blanched berries were subjected to sulphite treatment for one minute by dipping them in a solution containing sodium metabisulphite (one per cent SO_2) and citric acid (0.05 per cent) and the temperature of the solution was maintained at 70 °C. As control, blanched berries in distilled water kept at the aforesaid temperature were used.

3.4.5. Mechanical dehydration

The samples of berries obtained after kinetin and blanching treatments were dehydrated in electrically operated 'Cross-flow Air Oven' and 'Cabinet Drier'. In the initial phase of one hour, the temperature of the dehydrators was maintained at 70 °C. Later, it was reduced to 50 °C which was continued till the completion of dehydration when the moisture of the dehydrated material got reduced to about 10 per cent.

3.5. Evaluation of processing treatments

3.5.1 Organoleptic characters

Organoleptic test comprising of colour, appearance and texture was undertaken with the produce of different treatments. Colour grading was done as per 'Ganges Standard Colour guide'. Grading for appearance was rated visually as unsatisfactory, satisfactory and good. Texture was adjudged through feeling for softness and classification done as coarse, medium and fine.

3.5.2. Fixing best treatment combination

Based on the results of organoleptic evaluation, the best processing treatments of both the cultivars for every harvest stages were determined. The best treatments so identified were alone later subjected to further studies as detailed below.

3.6 Quality assessment of processed and fresh berries

On the Processed material the efficiency of retention of the following constituents was judged by comparing with that of fresh berries of the corresponding stages of harvest.

3.6.1. Moisture

The moisture content was determined adopting the technique of the Indian Standard Methods of Sampling and Test for Spices and Condiments (1974) using toluene as the extractant.

3.6.2. Chlorophyll

Chlorophyll was analysed after extraction in acetone by macerating one g sample of green berries in a mortar with a pinch of $CaCO_3$ to avoid pheophyten formation. Chlorophyll estimation was done by recording the differential absorptivity of the filtered extract at 663 and 645 nm as suggested by Starnes and Hadley (1968). The total chlorophyll was estimated using the following formula.

$$\text{Total Chlorophyll mg/g} = 8.05\, A_{663} + 20.29\, A_{645}$$

Where A is the absorptivity.

3.6.3. Volatile oil

Volatile oil was extracted using 10 g samples by water distillation for two hours adopting Clevenger distillation method and the data were expressed in percentage (ASTA, 1960).

3.6.4. Piperine

Piperine was extracted from 5g samples by distillation for two hours in 95 per cent ethanol. The filterate was reduced by evaporation at low temperature and 10 ml ethanolic KOH was added and kept over night. The yellow needles of piperine crystel were separated and their weight recorded (Ikan, 1969).

3.6.5. Nonvolatile ether extract (NVEE)

The NVEE was estimated after extraction of 2 g samples in anhydrous ether for 20 hours. The ether in the extract was first allowed to evaporate at room temperature and finally at 110 °C in a drying oven until constant weight is obtained. The weight of the residue so obtained was recorded as NVEE (Hart and Fisher, 1971).

3.6.6. Starch

Two g samples were chosen for starch estimation. Separation of soluble sugars was done by extracting in alcohol. The starch fraction was hydrolysed to soluble fractions twice with 52 per cent perchloric acid at 0 °C for 20 minutes and the content was estimated adopting anthrone method. The conversion factor of 0.9 was used to calculate the starch content as suggested by Mc - Cready et al. (1950).

3.6.7. Crude Fibre

The estimation of crude fibre content was done from the defated samples (after extraction of NVEE/piperine).

The fat free material was treated successively with 1.25 per cent H_2SO_4 and 1.25 per cent NaOH. The weight of the material left undissolved less the weight of its ash was worked out as crude fibre (AOAC, 1970).

3.6.8 Ash

Total ash was estimated by igniting two g samples at 500-550 °C to white ash. The acid insoluble ash was estimated by digestion with (1:1, V/V) dilute HCl.

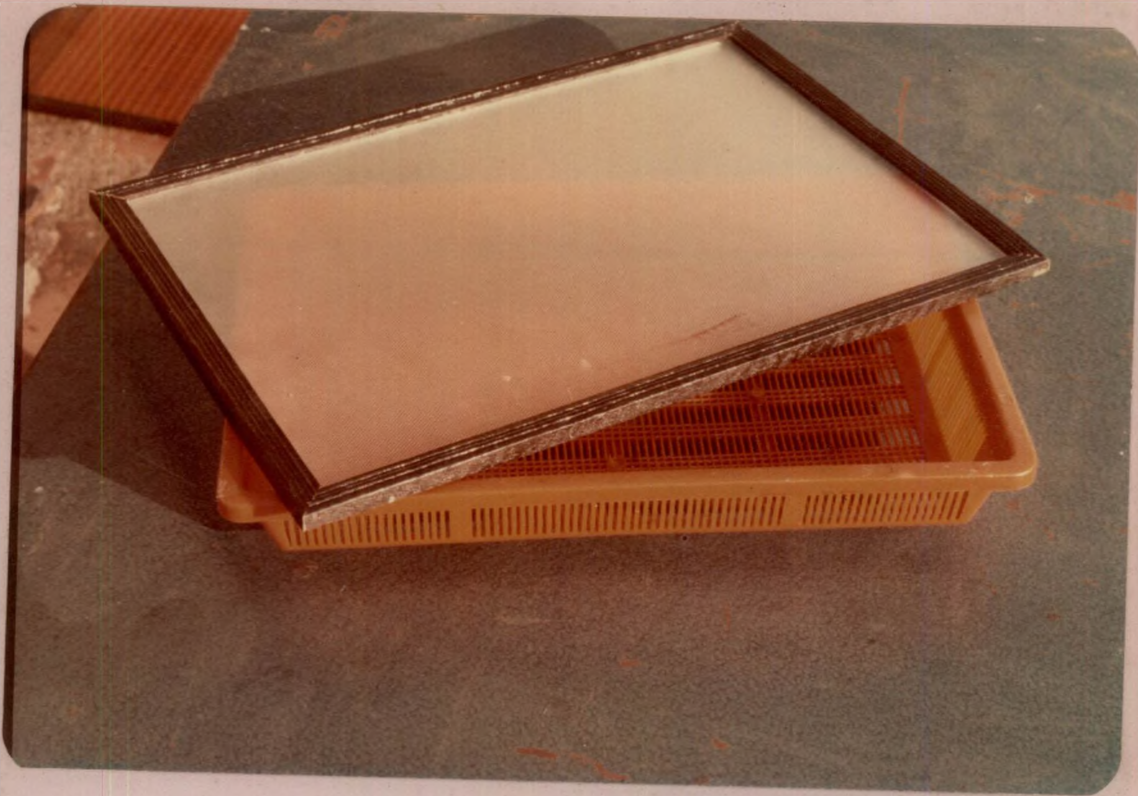
3.7. Solar dehydration

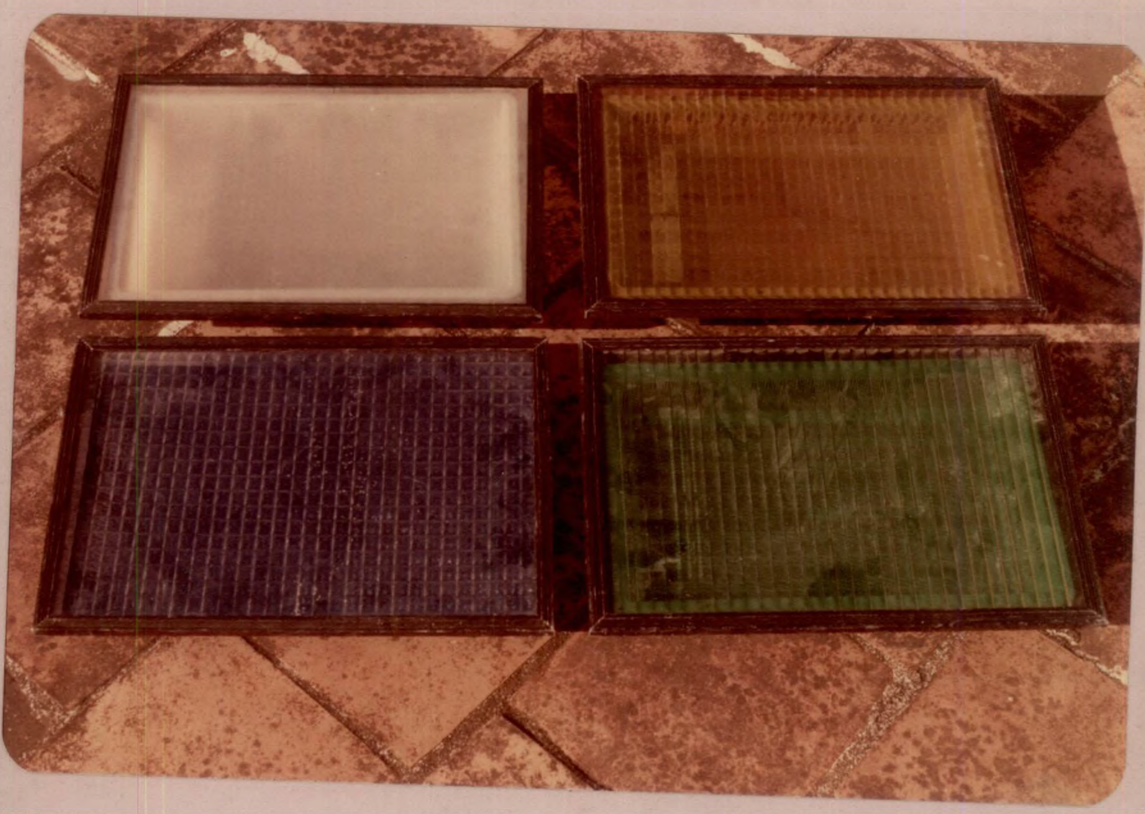
The samples of berries obtained out of the best processing treatment combinations were subjected to solar dehydration to compare its efficiency with mechanical dehydration.

A special type of plastic drying chamber fit for fixing glass covers (filters) was selected (plate I a). To allow free escaping of moist air, Ventillation was provided to the chamber on all its four sides and also at the bottom. Ground glass of assorted colours viz., green, blue, amber and white were used as covers of chambers to obtain filtered light of specific wave lengths on the berries (Plate I-b). The wave lengths of filtered light passing through the coloured glass covers were determined using Spectronic-20. To serve as control, drying in open sun was also resorted to.

PLATE I a - Drying Chamber (after displacing filter glass)

PLATE I b - Drying Chambers with different filter glasses in position.





The dehydrated material so obtained under different treatments were then subjected to organoleptic evaluation as detailed in para 3.5.1.

3.8. Dehydration and rehydration ratios

The dehydration ratio was worked out based on the quantity of raw material used and the recovery obtained after processing.

The rehydration efficiency of the processed produce was judged by keeping in water at room temperature and at 70 °C. Based on the gain in the weight of the rehydrated material, rehydration ratio was worked out.

3.9. Storage efficiency

The following storage methods were tested for their efficiency

(i) Brown paper lined wooden boxes.

(ii) Black polythene lined wooden boxes.

(iii) Aluminium foil lined wooden boxes.

(iv) Transparent polythene lined wooden boxes. (Control)

The extent of protection afforded against ingress of moisture and retention of quality attributes was assessed till three months of storage in different storage receptacles.

3.10. Economics of processing

Cost of production of one kg of dehydrated green pepper was worked out and compared with the conventional production cost of equivalent quantity of black pepper. A comparison on the relationship existing between treatments in respect of their raw material requirement was also made to enable the industry to procure berries at the desired maturity stages that too safe guarding the interests of the cultivators.

RESULTS

RESULTS

Investigation was carried out to standardise techniques for retention of green colour in processed pepper. Results of the studies are presented in this chapter.

4.1. Selection of green pepper berries

The data on the recovery percentage of uniform green pepper berries from different harvest stages suitable for processing are presented in Table 2.

Table 2. Recovery percentage of ideal pepper berries for processing, from different harvest stages.

Stages of harvest	Percentage of recovery Karimunda	Panniyoor-I
(1)	(2)	(3)
I	34.0	32.8
II	35.3	34.0
III	38.0	40.5
IV	47.8	47.2
V	47.9	48.0

The percentage of recovery of pepper berries suitable for processing was on the increase towards maturity of berries in both the cultivars. Though the recovery in Panniyoor-I was slightly lesser in the Ist stage, it was more or less par with Karimunda in the Vth stage.

4.2. Processing treatments

4.2.1. Kinetin

On dehydration, the kinetin treated berries devoid of blanching were of uniform black colour and were not superior over control in respect of the organoleptic characters, viz. colour, appearance and texture.

4.2.2. Blanching

The blanching treatments at varying levels caused distinct variation in colour and other characters in the dehydrated product. The blanching requirement for the retention of green colour, was found related to the maturity stages of the raw material. The optimum blanching requirement for the IInd, IIIrd and IVth stages were found to be 10,12.5 and 15 minutes respectively. But in respect of the berries harvested at the Vth stage, none of the treatments was helpful to retain the desired colour. On the contrary, the blanching of fully matured berries led to quality deterioration in respect of colour appearance and texture.

The preblanching treatment with kinetin also did not help in colour retention as the standard of the produce was similar to control.

4.2.2.1 Magnesium Sulphate

The magnesium sulphate in the blanching media was effective in retention of green colour in berries, the concentration required being proportional to the maturity of the berries. The requirement of magnesium sulphate in the blanching media was one per cent for the IInd and IIIrd stages, whereas, it was 2.5 per cent for the IVth stage. However, much variation in this respect was noticed in Vth stage, for which, the range from 1 to 5 per cent was not effective for the colour retention on berries.

4.2.2.2. Ascorbic acid

Ascorbic acid treatment was also useful for retention of colour in berries. But, no difference in effect could be noticed between the two concentrations tried.

4.2.3. Sulphite treatment

Post blanching treatment with a solution of sodium metabisulphite and citric acid was found very effective in the retention of green colour in berries. While the treated berries possessed well pronounced colour, the produce obtained from control had a blackish tinge.

4.2.4. Mechanical dehydration.

Of the two mechanical dehydration methods adopted, Cross-flow Air Oven drying helped to obtain well pronounced bright coloured berries which were superior to the product obtained from Cabinet Drier in colour expression. The produce obtained from the Cabinet Driver was dull and poor in appearance.

4.3. Evaluation of processing treatments.

4.3.1. Organoleptic characters

The evaluation of dehydrated produce with reference to treatments for organoleptic characters (colour, appearance and texture) are presented in Table 3.

TABLE -3. Organoleptic evaluation of promising processing treatments under varying blanching levels.

Stages of harvest	Characters evaluated	Blanching period	10 Minutes		12.5 Minutes		15 Minutes	
		Cultivar	Karimunda	Panniyoor-I	Karimunda	Panniyoor-I	Karimunda	Panniyoor-I
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)
II	Colour		Vivid green	light green	Bleached light green patches	Bleached light green patches	Fully Bleached	Fully Bleached
	Appearance		Good	Good	Unsatis-factory.	Unsatis-factory.	Unsatis-factory	Unsatis-factory.
	Texture		Fine	Fine	Medium	Medium	Coarse	Coarse
III	Colour		Bronze brown	Sepia	Process green	Middle green	Bleached light green patches	Bleached light green patches
	Appearance		Unsatis-factory.	Unsatis-factory.	Good	Satisfa-ctory.	Unsatis-factory.	Unsatis-factory
	Texture		Fine	Fine	Fine	Fine	Medium	Medium
IV	Colour		Black	Black	Sepia	Mahagony brown	Pea green	Neobright green
	Appearance		Unsatis-factory	Unsatis-factory	Unsatis-factory	Unsatis-factory	Good	Good
	Texture		Medium	Medium	Fine	Fine	Fine	Fine
V	Colour		Black	Black	Bronze brown	Sepia	Light green tinge	Very light green tinge
	Appearance		Unsatis-factory	Unsatis-factory	Unsatis-factory	Unsatis-factory	Unsatis-factory	Unsatis-factory
	Texture		Medium	Medium	Medium	Medium	Fine	Fine

Evaluation detailed in Table 3 indicated that the green colour retention remained restricted to a certain level of blanching depending on the maturity of the berries. The blanching treatment higher to this level had resulted in bleaching of the berries, whereas, lower levels either imparted black or brown colour to the berries. The appearance of the berries was also indicative of the efficiency of retention of green colour. The texture of the berries improved much at optimum level of blanching. Berries got malformed under prolonged blanching.

4.3.2. Fixing of best treatment combination.

Based on the organoleptic evaluation of the processed material as in Table 3, three stages of harvests (second, third and fourth) were found promising for further studies. Their requirements of processing are furnished in Table-4 along with the details of the fifth stage for comparison although it was found inferior.

Table -4. The best treatment combinations retaining green colour on dehydration of pepper berries of varying maturity.

Stage of harvest	Blanching time (Minutes)	Additive to blanching media		Sulphite treatment	
		$MgSO_4$ %	Ascorbic acid %	SO_2 % (Sodium metabisulphite)	Citric acid %
(1)	(2)	(3)	(4)	(5)	(6)
II	10	1.0	0.025	1.0	0.05
III	12.5	2.5	0.025	1.0	0.05
IV	15.0	2.5	0.025	1.0	0.05
V	15.0	5.0	0.05	1.0	0.05

The dehydrated samples obtained out of different processing techniques along with the fresh and rehydrated berries are presented in Plates II to V.

PLATE II a - Pepper berries - Immature (Stage II - 4 months old) - Karimunda.

A - Fresh pepper berries.

B - Dehydrated pepper berries.

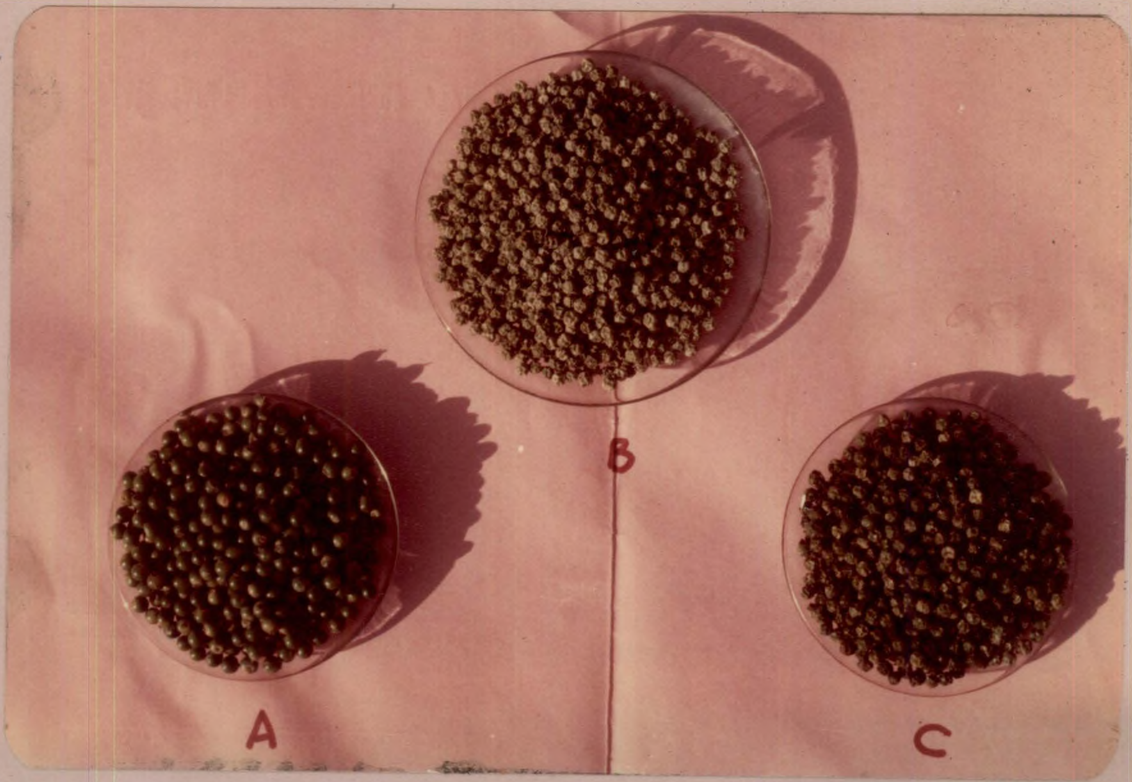
C - Rehydrated pepper berries.

PLATE II b - Pepper berries - Immature (Stage II - 4 months old) Panniyoor-I.

A_1 - Fresh pepper berries.

B_1 - Dehydrated pepper berries.

C_1 - Rehydrated pepper berries.


B
A
C

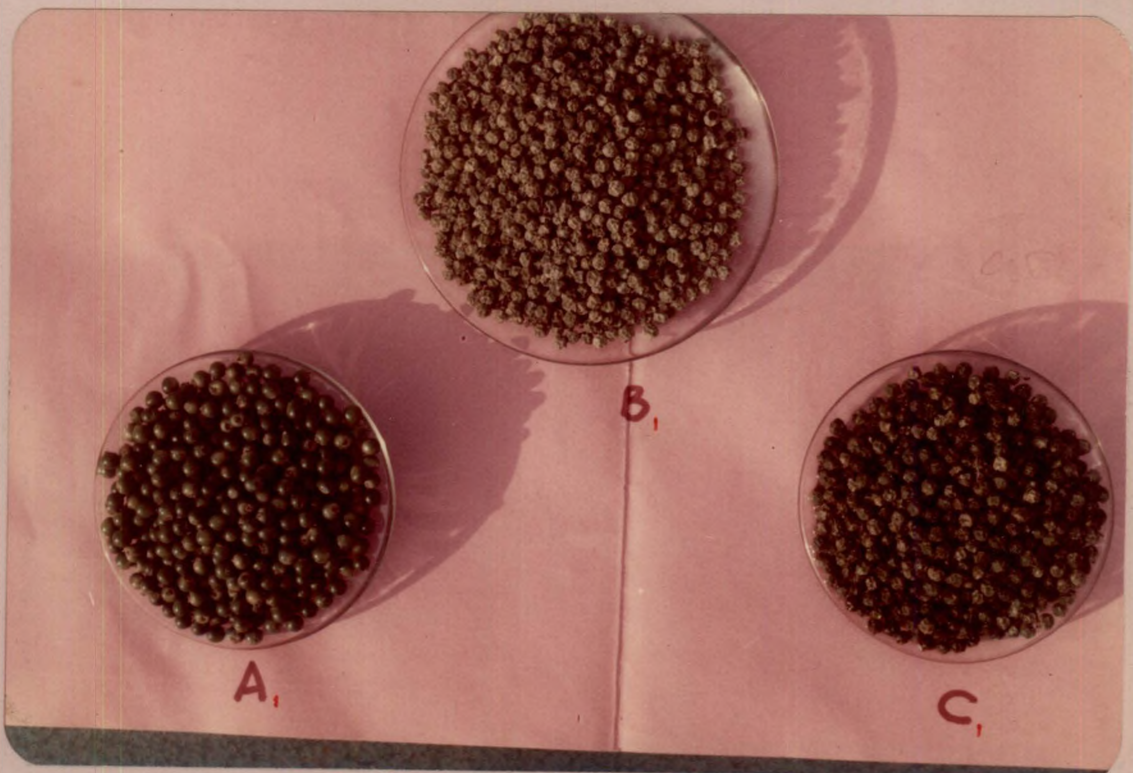

B1
A1
C1

PLATE III a - Pepper berries - Immature
(Stage III - 5 months old)
Karimunda.

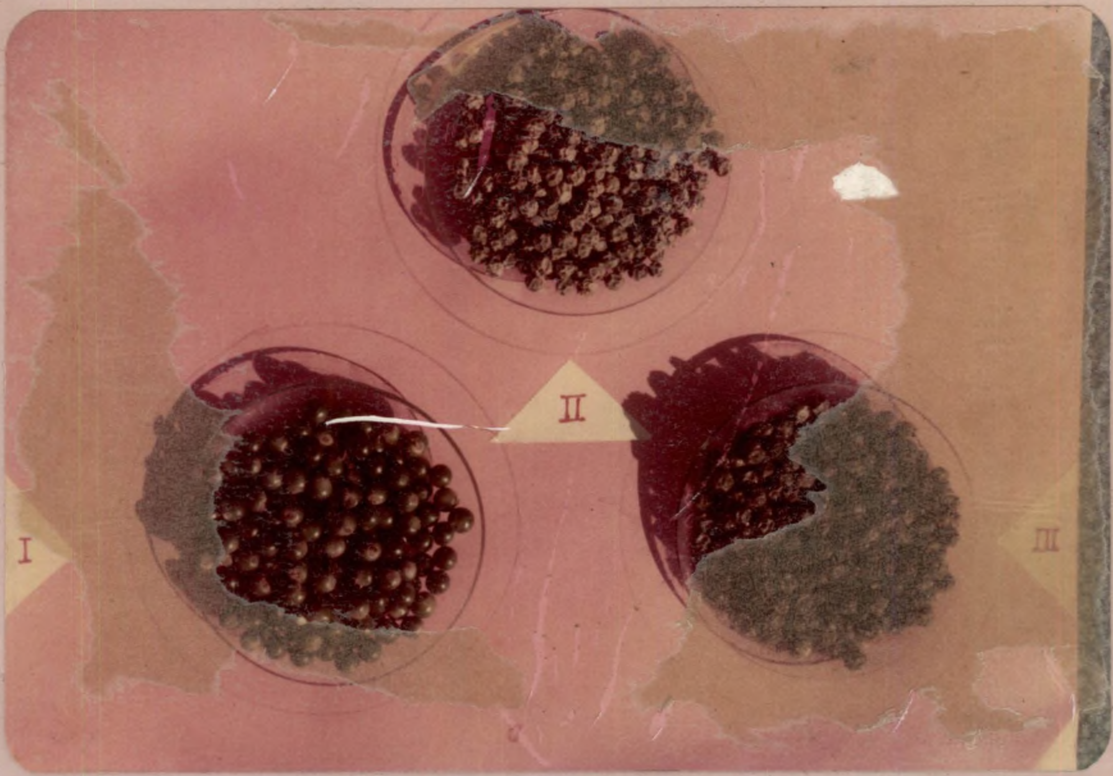
I - Fresh pepper berries.

II - Dehydrated pepper berries.

III - Rehydrated pepper berries.

PLATE III b - Pepper berries - Immature
(Stage III - 5 months old)
Panniyoor-I

1 - Fresh Pepper berries.
2 - Dehydrated pepper berries.
3 - Rehydrated pepper berries.


I
II
III

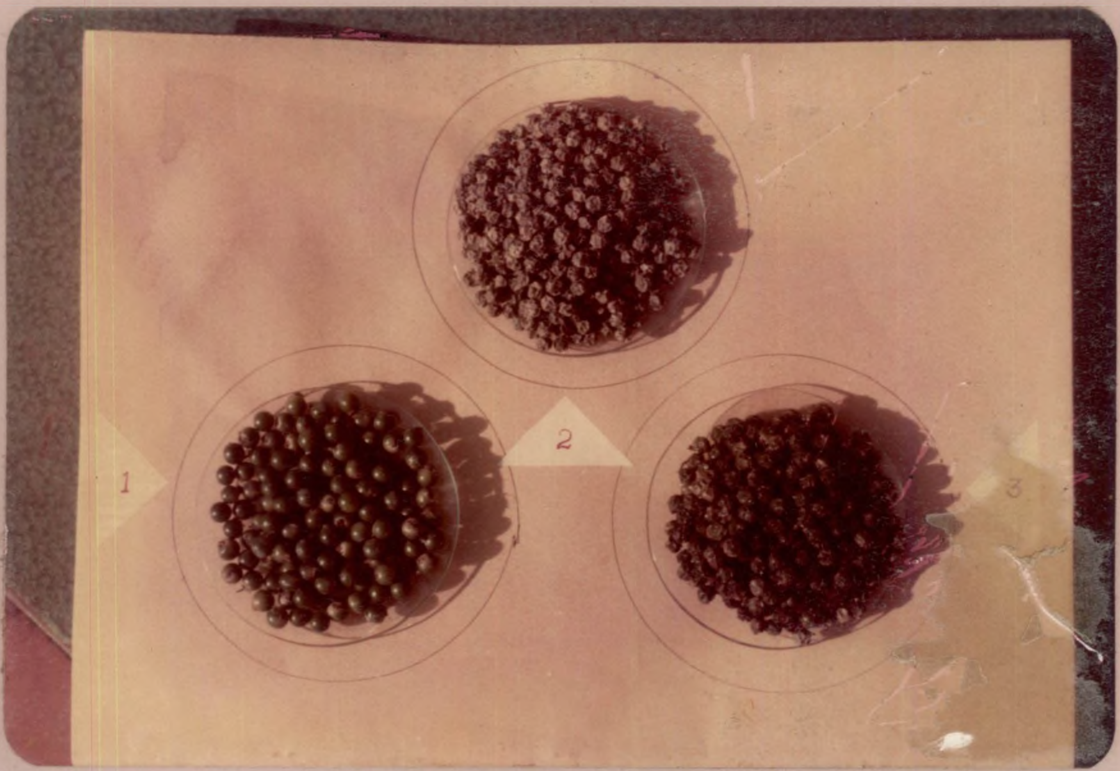

1
2
3

PLATE IV a - Pepper berries - Immature (Stage IV - 5½ months old) - Karimunda.

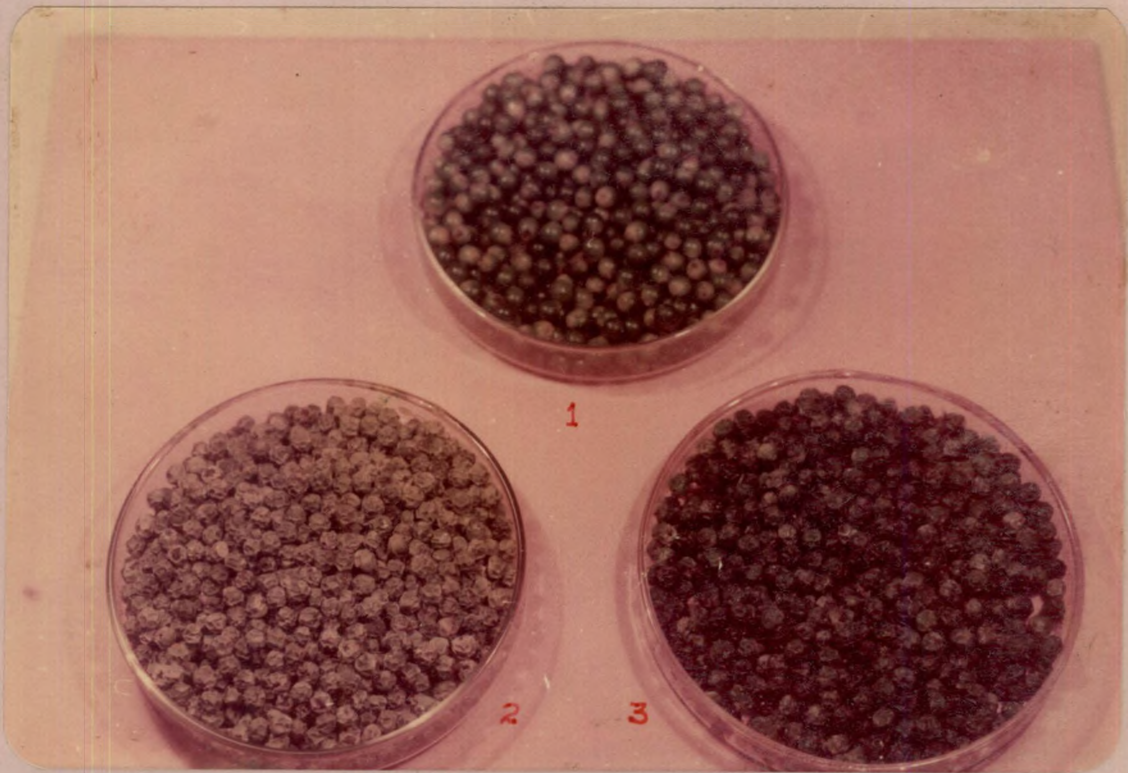
1. Fresh pepper berries.
2. Dehydrated pepper berries.
3. Rehydrated pepper berries.

PLATE IV b - Pepper berries - Immature (Stage IV - 5½ months old) - Panniyoor-I

I - Fresh pepper berries.

II - Dehydrated pepper berries.

III - Rehydrated pepper berries.


1
2
3


I
II
III

PLATE V a - Pepper berries - Mature (Stage V - 6 months old)- Karimunda.

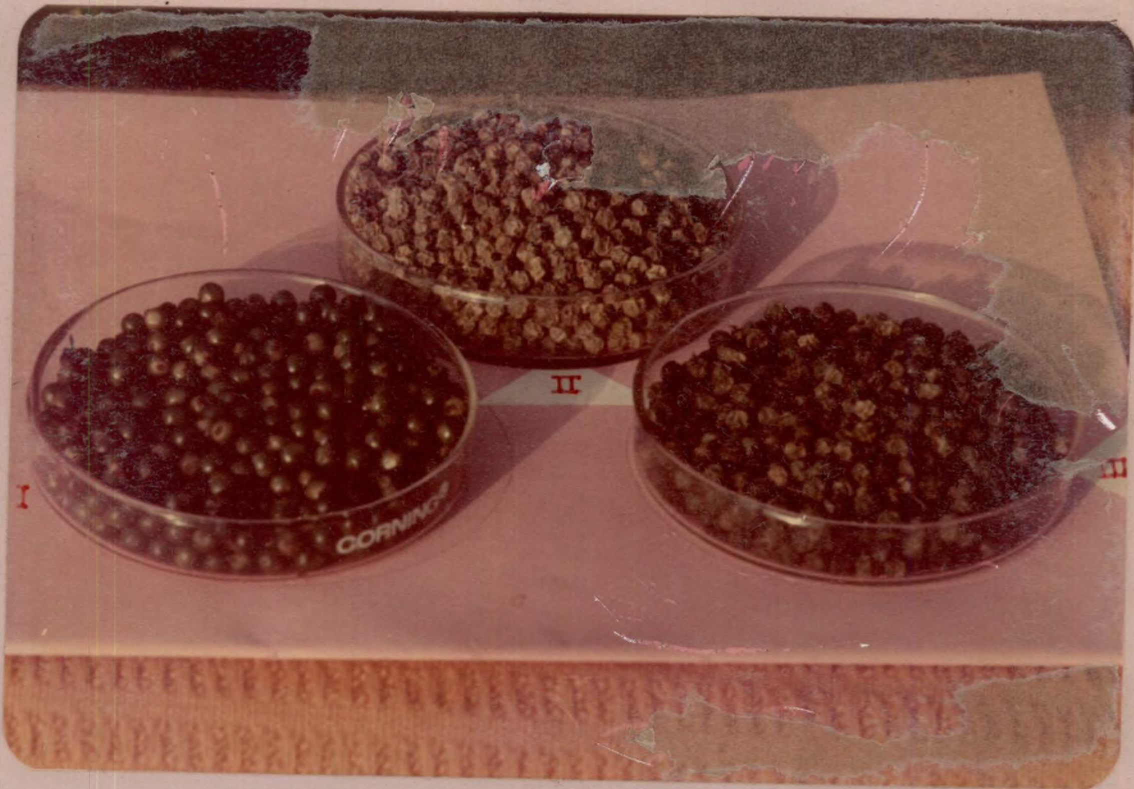
I - Fresh pepper berries.

II - Dehydrated pepper berries.

III - Rehydrated pepper berries.

PLATE V b - Pepper berries - Mature (Stage V - 6 months old)- Panniyoor-1

1. Fresh pepper berries.
2. Dehydrated pepper berries.
3. Rehydrated pepper berries.


II
I
CORNING
III


2
1
CORNING
3

4.4. Quality assessment of processed and fresh berries.

4.4.1. Moisture

The moisture content in fresh and processed berries are furnished in Table 5.

Table-5 : Moisture content in fresh and processed pepper berries at different harvest stages.

Stage of harvest	Moisture content in percentage			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	79.40	-	80.35	-
II	75.90	9.20	76.30	9.50
III	70.40	8.90	70.65	9.10
IV	67.30	9.50	66.60	10.10
V	62.30	8.50	61.80	9.20

The moisture content of the fresh berries of both the cultivars showed a decreasing trend as their maturity advanced. The same which was more in Panniyoor-I in the Ist stage got reduced by 18.55 per cent at the Vth stage. In Karimunda the reduction during the corresponding period was only 17.1 per cent. In the processed berries the moisture content was limited to around 10 per cent.

4.4.2. Chlorophyll

The chlorophyll content in fresh and processed berries at different harvest stages are given in Table 6 and Fig. 1 a and 1 b.

Table-6 Chlorophyll content in fresh and processed pepper berries at different harvest stages.

(Data in parenthesis indicate percentage of retention).

Stages of harvest	Chlorophyll content (mg/g) on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	3.10	-	2.67	-
II	2.72	1.87 (68.75)	2.41	1.59 (65.98)
III	1.83	1.41 (77.04)	1.67	1.32 (79.04)
IV	1.03	0.79 (76.69)	0.82	0.63 (76.83)
V	0.47	0.19 (40.42)	0.39	0.12 (30.77)

In both the cultivars, chlorophyll contained in the berries showed a declining trend towards the maturity of the berries. It was more in Karimunda in all the stages of development compared to Panniyoor-I.

In both the cultivars the berries harvested at the IIIrd stage were found most efficient with regard to the retention of chlorophyll after processing.

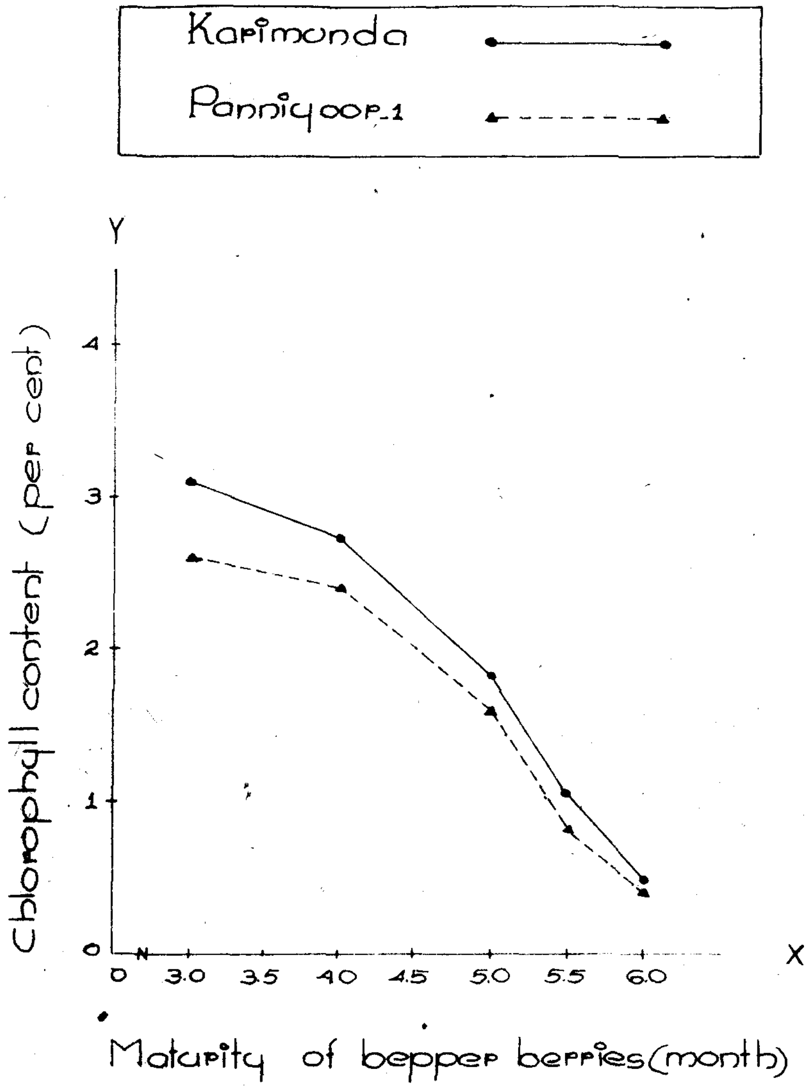


Fig. 1a - Chlorophyll content in fresh pepper berries (dry weight basis)

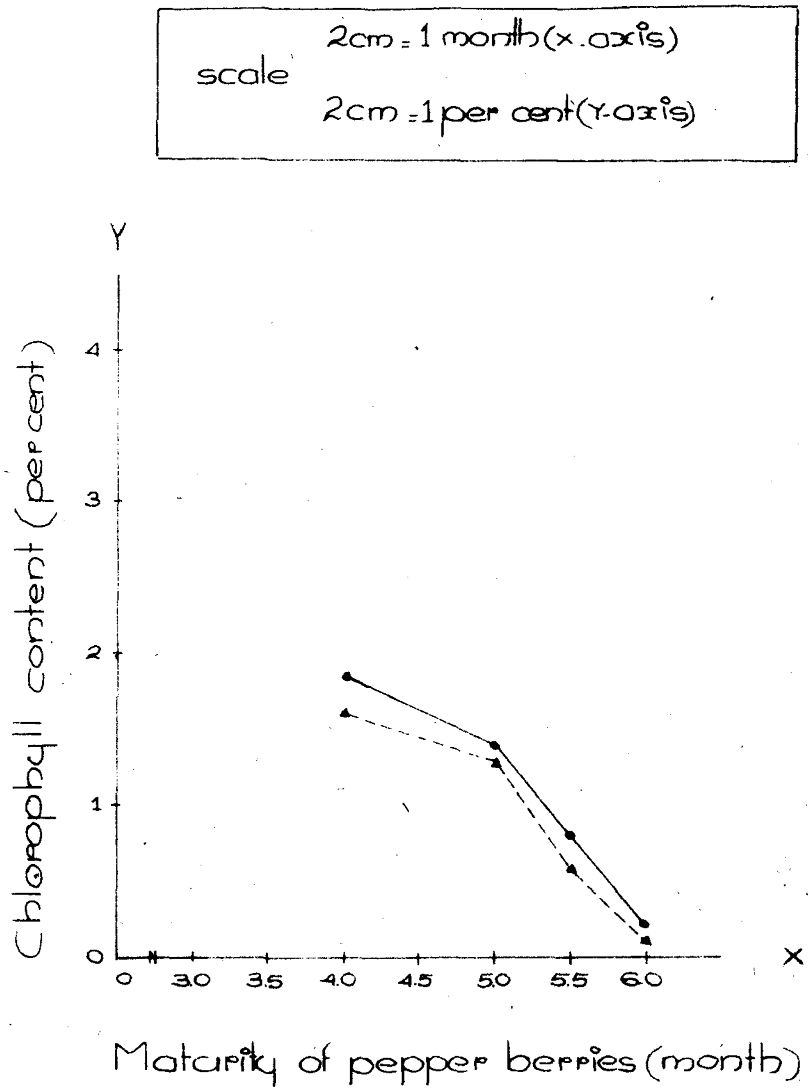


Fig. 1a. Chlorophyll content in the dehydrated green pepper berries

4.4.3. Volatile Oil

The data present in Table 7 and Fig. 2 a and 2 b indicates the volatile oil content of fresh and processed berries at different maturity levels.

Table 7. Volatile oil content in fresh and processed pepper berries at different harvest stages.

(Data in parenthesis indicate percentage of retention)

Stages of harvest	Percentage of volatile oil on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	10.1	-	8.3	-
II	10.4	3.1 (29.8)	9.1	2.7 (29.7)
III	9.6	4.0 (41.6)	8.2	3.8 (46.4)
IV	6.8	3.7 (54.4)	5.1	2.9 (56.9)
V	3.7	2.9 (78.4)	2.9	2.1 (72.4)

The data revealed that there was wide variation in the accumulation pattern of volatile oil in the fresh berries depending on the stages of maturity. But the pattern of accumulation was quite similar in both the cultivars, which was at a peak in the IInd stage and declining trend thereafter.

Due to processing treatments there was loss in the volatile oil content in both the cultivars. Retention of volatile oil in the berries was minimum in the IInd stage which increased gradually as the maturity of the berry advanced.

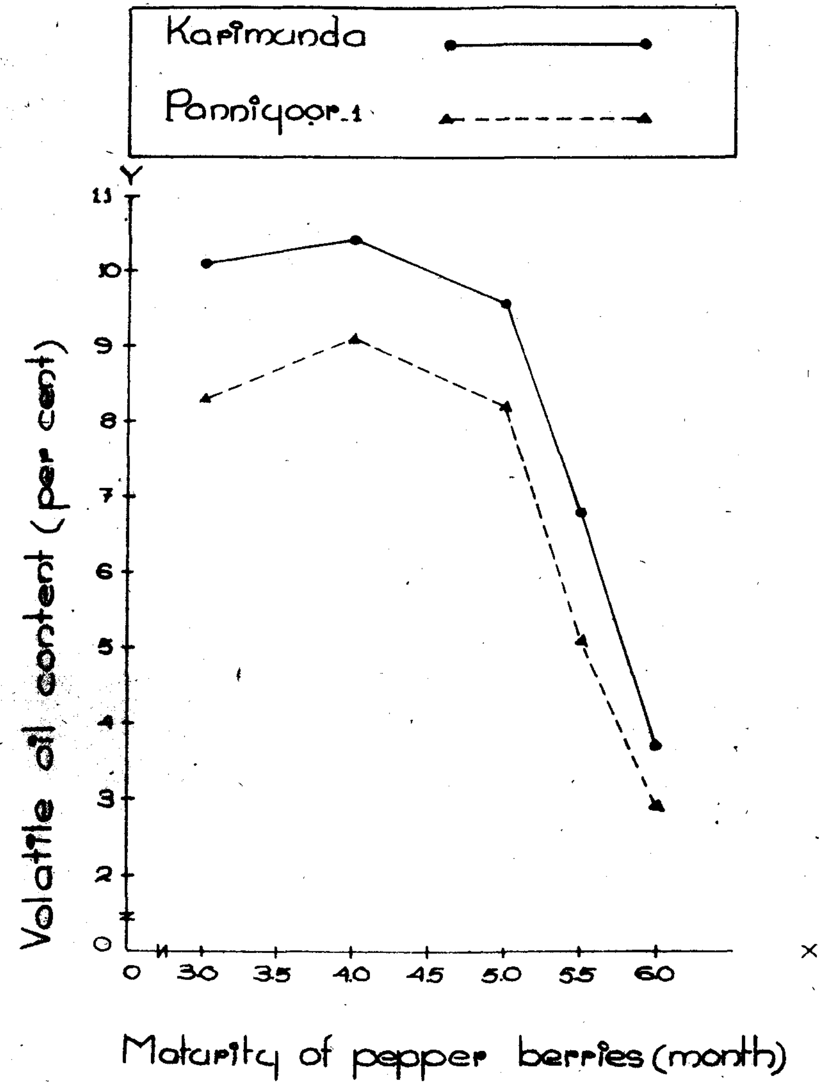


Fig.2a. Volatile oil content in fresh pepper berries (dry weight basis)

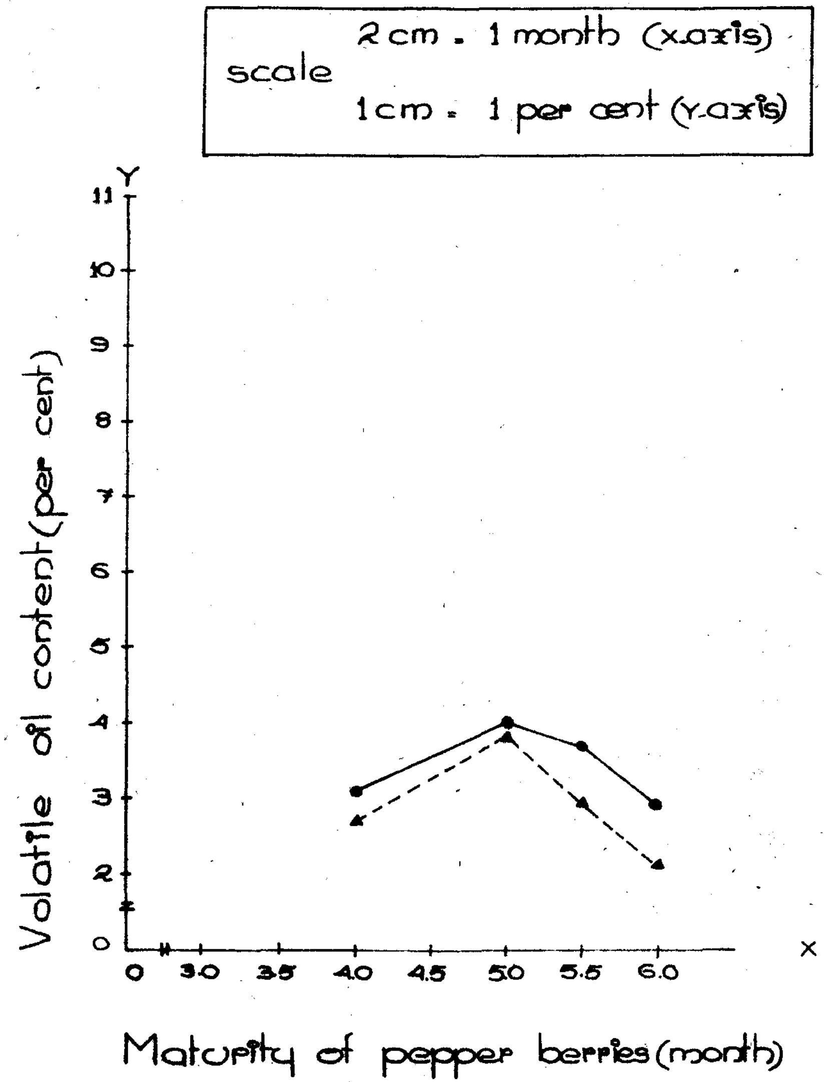


Fig. 2b. Volatile oil content in the dehydrated green pepper berries

4.4.4. Piperine

The data regarding the piperine content in fresh and processed pepper berries at various maturity levels are given in Table 8 and Fig. 3 a and 3 b.

Table-8. Piperine content in fresh and processed pepper berries at different harvest stages.

Stages of harvest	Percentage of piperine on dry weight basis			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	5.2	-	4.8	-
II	6.5	5.9	6.3	5.3
III	6.8	6.6	6.0	6.2
IV	4.6	4.7	4.1	4.4
V	4.0	4.2	3.4	3.6

Wide variation in the accumulation pattern of piperine could be noticed in berries during their course of development. Variation could also be observed between the cultivars. The peak accumulation was noticed in the IInd stage in Panniyoor-I and IIIrd stage in Karimunda. There after it declined.

Higher piperine content was observed in the processed berries of IVth and Vth stages in Karimunda and III, IV and V stages in Panniyoor-I compared to the fresh ones. Marginal loss of piperine content during processing was noticed in the berries harvested in the IInd and IIIrd stages in Karimunda and IInd stage alone in Panniyoor-I.

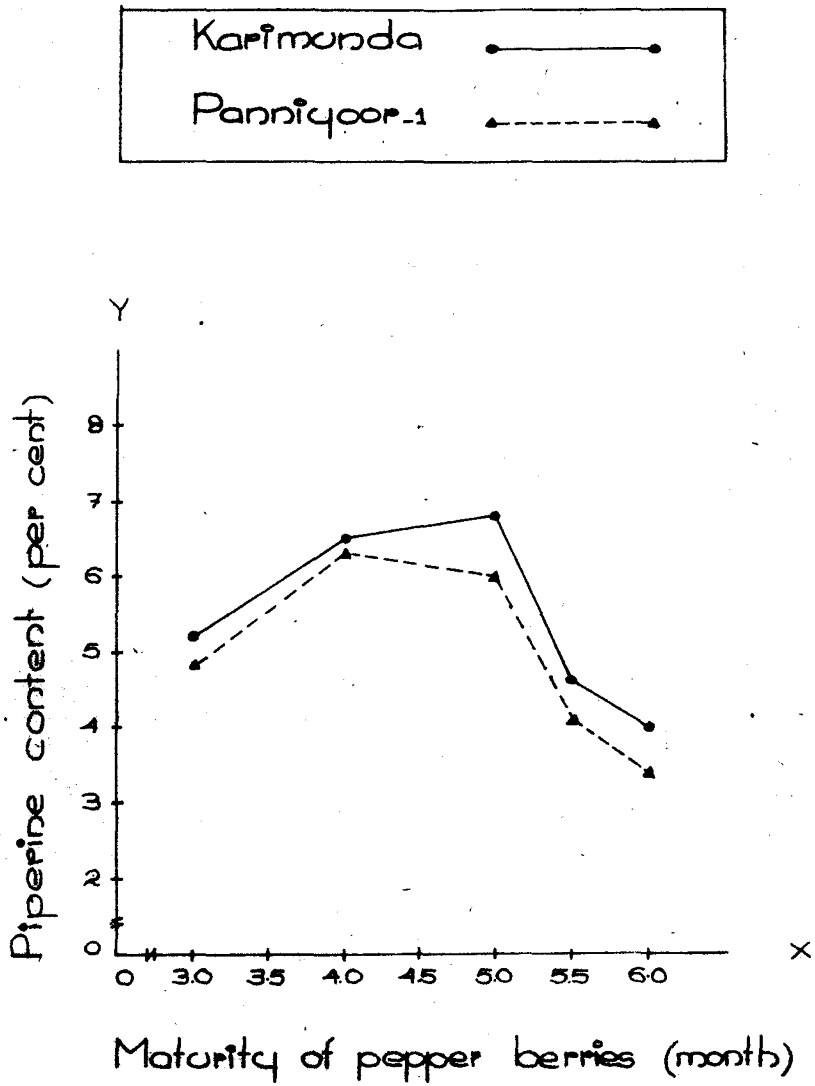


Fig.3a - Piperine content in fresh pepper berries (dry weight basis)

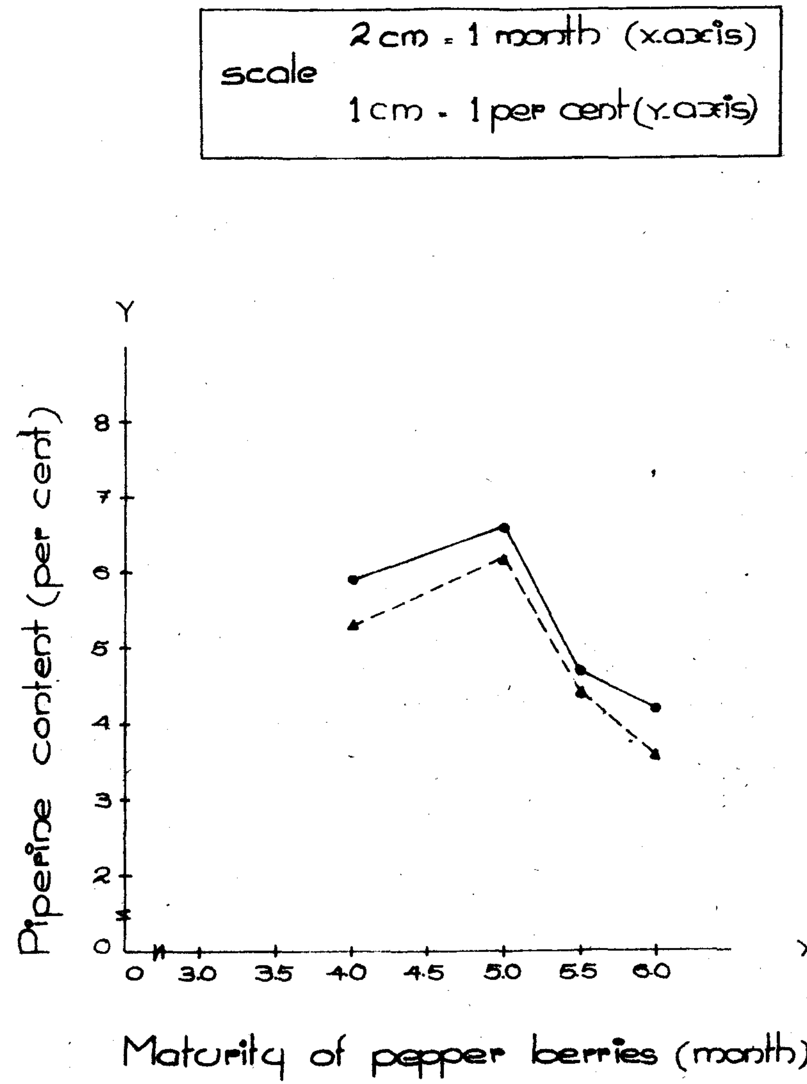


Fig.3b - Piperine content in the dehydrated green pepper berries.

4.4.5 Nonvolatile ether extract (NVEE)

The data presented in Table 9 and Fig. 4 a and 4 b revealed the NVEE content in fresh and processed pepper berries at different harvest stages.

Table 9. Nonvolatile ether extract content in fresh and processed pepper berries at different harvest stages.

(Data in parenthesis indicate percentage of retention)

Stages of harvest.	Percentage of NVEE on dry weight basis			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	10.5	-	9.3	-
II	9.3	6.7 (72.1)	8.9	6.9 (77.5)
III	8.8	7.2 (81.8)	8.3	7.4 (89.2)
IV	7.6	6.3 (82.9)	8.0	7.2 (90.0)
V	7.2	6.0 (83.3)	7.6	6.5 (85.5)

In respect of NVEE content a declining trend towards the development of berries was noticed in both the cultivars. The variation in Panniyoor-I was marginal compared to Karimunda.

The NVEE content got reduced during processing. Percentage retention was maximum in processed berries of IVth stage in Panniyoor-I and Vth stage in Karimunda.

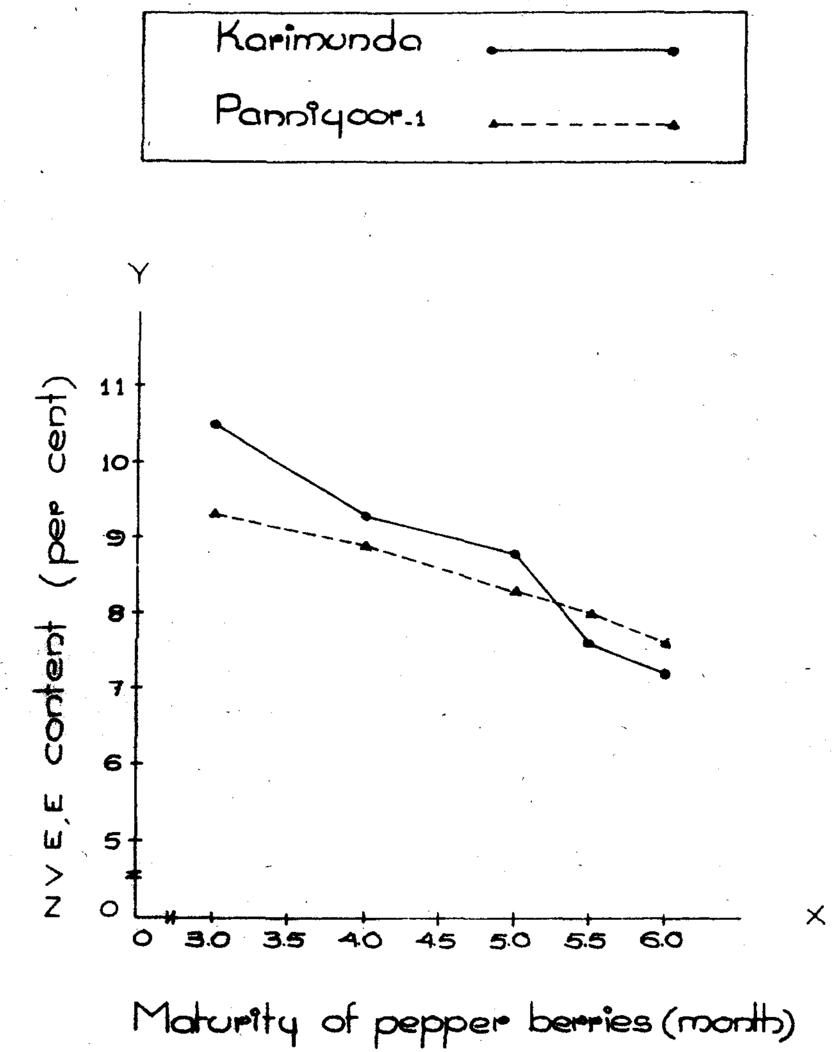


Fig.4a. Nonvolatile ether extract in fresh pepper berries. (dry weight basis)

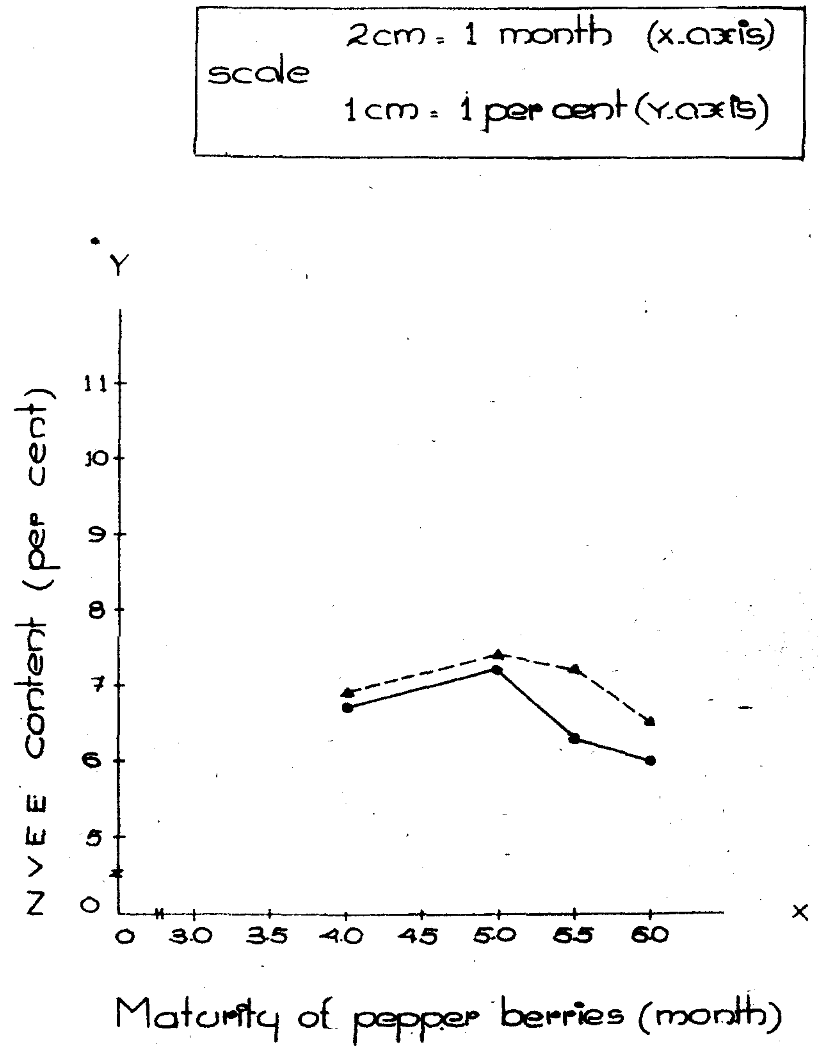


Fig.4b. Nonvolatile ether extract in the dehydrated green pepper berries.

4.4.6. Starch

The starch content in fresh and processed pepper berries at different stages of harvest are presented in Table 10 and Fig. 5 a and 5 b.

Table 10. Starch content in fresh and processed pepper berries at different harvest stages.

Stages of harvest	Percentage of starch on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	17.35	-	19.42	-
II	21.42	22.10	21.90	23.00
III	26.60	27.30	25.35	26.90
IV	38.47	40.80	38.57	41.10
V	42.70	43.20	43.20	44.80

The accumulation pattern of starch exhibited an increasing trend during the course of development of berries. The rate of increase was slower in the initial stages. It became rapid as the maturity of the berries advanced in both the cultivars. Starch content was higher in processed berries compared to the fresh ones of the corresponding stages in both the cultivars.

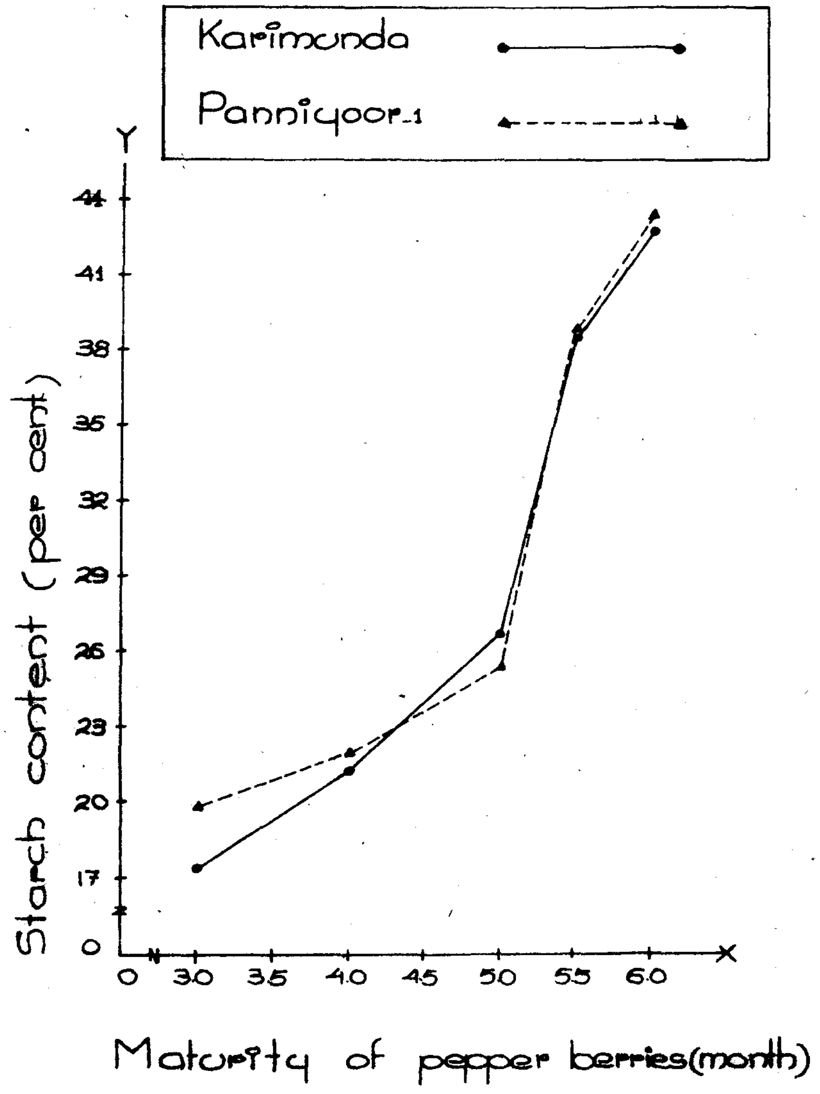


Fig.5a. Starch content in fresh pepper berries (dry weight basis)

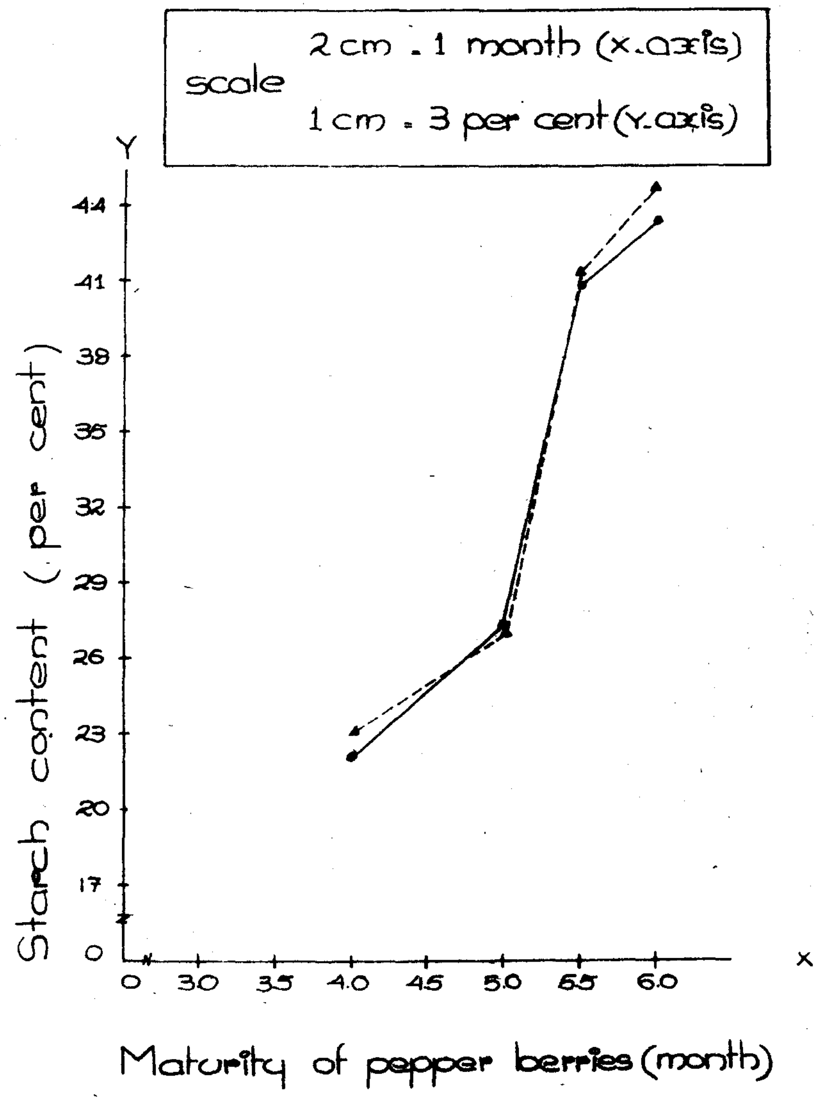


Fig.5b. Starch content in the dehydrated green pepper berries

4.4.7. Crude fibre.

The data depicted in Table 11 and Fig. 6 a and 6 b indicate the crude fibre content in fresh and processed pepper berries at different stages of harvest.

Table 11. Crude fibre content in fresh and processed pepper berries at different harvest stages.

Stages of harvest	Percentage of crude fibre on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	20.17	-	21.85	-
II	19.56	22.35	18.10	21.80
III	13.50	16.90	16.05	19.20
IV	12.82	15.75	15.15	18.10
V	11.87	13.50	12.90	14.35

The content of crude fibre exhibited a declining trend with the advancement in the development of berries in both the cultivars. The accumulation was found to be more in immature stages compared to mature berries irrespective of the cultivars.

Crude fibre content was higher in the processed berries compared to the fresh ones.

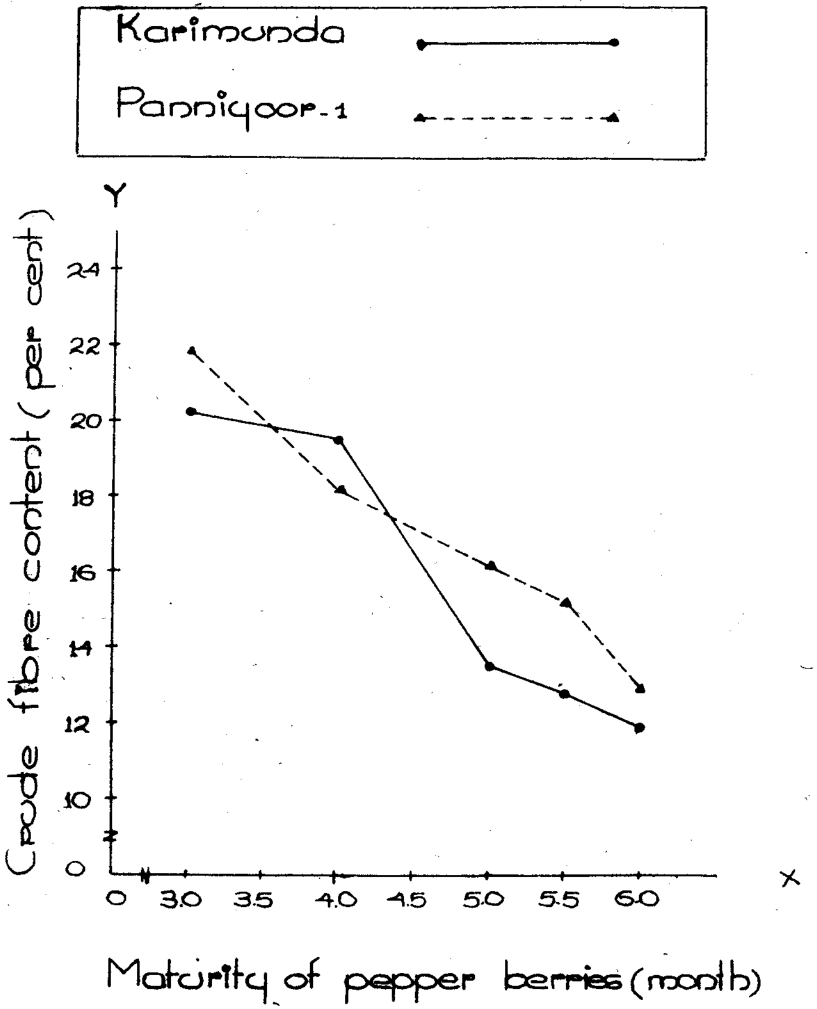


Fig.6.a. Crude fibre content in fresh pepper berries.(dry weight basis)

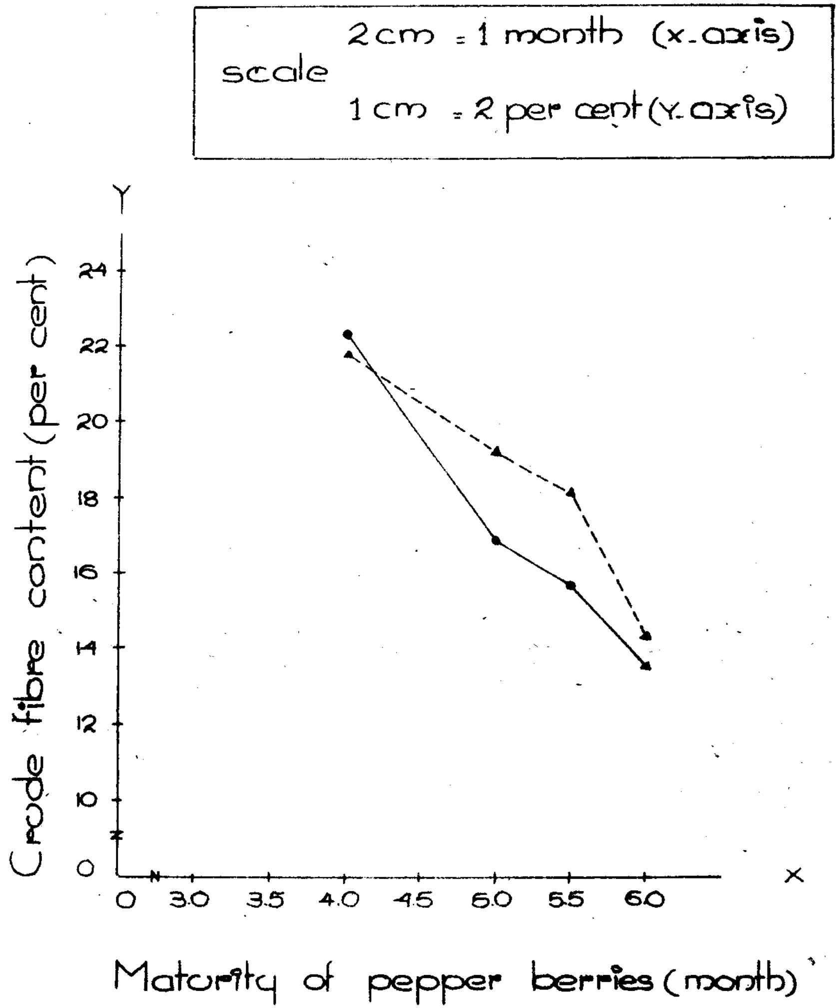


Fig.6b. Crude fibre content in the dehydrated green pepper berries

4.4.8. Ash

4.4.8.1. Total ash

The data presented in Table 12 and Fig. 7 a and 7 b show the total ash content in fresh and processed pepper berries at different stages of harvest.

Table 12. Total ash content in fresh and processed pepper berries at different harvest stages.

Stages of harvest.	Percentage of ash on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	5.81	-	7.20	-
II	6.56	6.95	6.21	6.80
III	4.95	6.10	5.48	5.60
IV	4.43	5.78	5.43	5.65
V	4.12	4.95	5.10	5.30

The accumulation pattern of total ash differed at varying maturity levels of berries in both the cultivars. The peak accumulation was in the Ist stage in Panniyoor-I and in IInd stage in Karimunda. Thereafter a gradual decrease was observed in both the cultivars till maturity. The total ash content was higher in processed berries, compared to the fresh ones in both the cultivars.

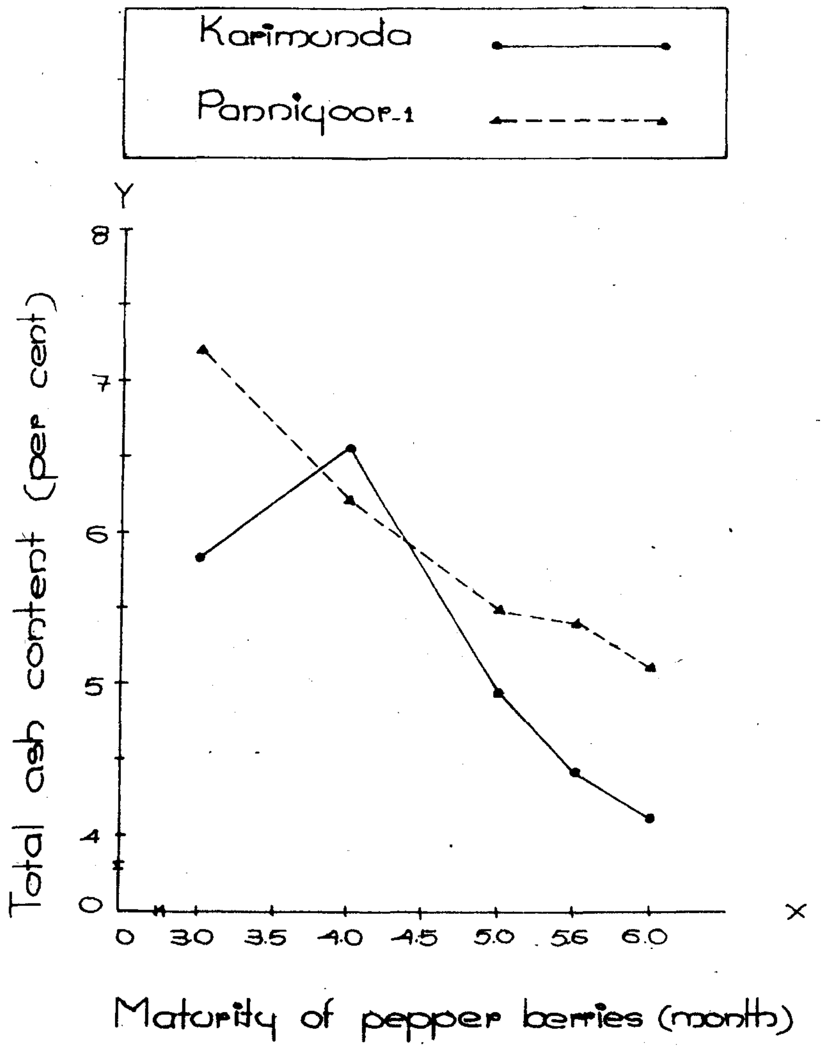


Fig.7a- Total ash in fresh pepper berries (dry weight basis)

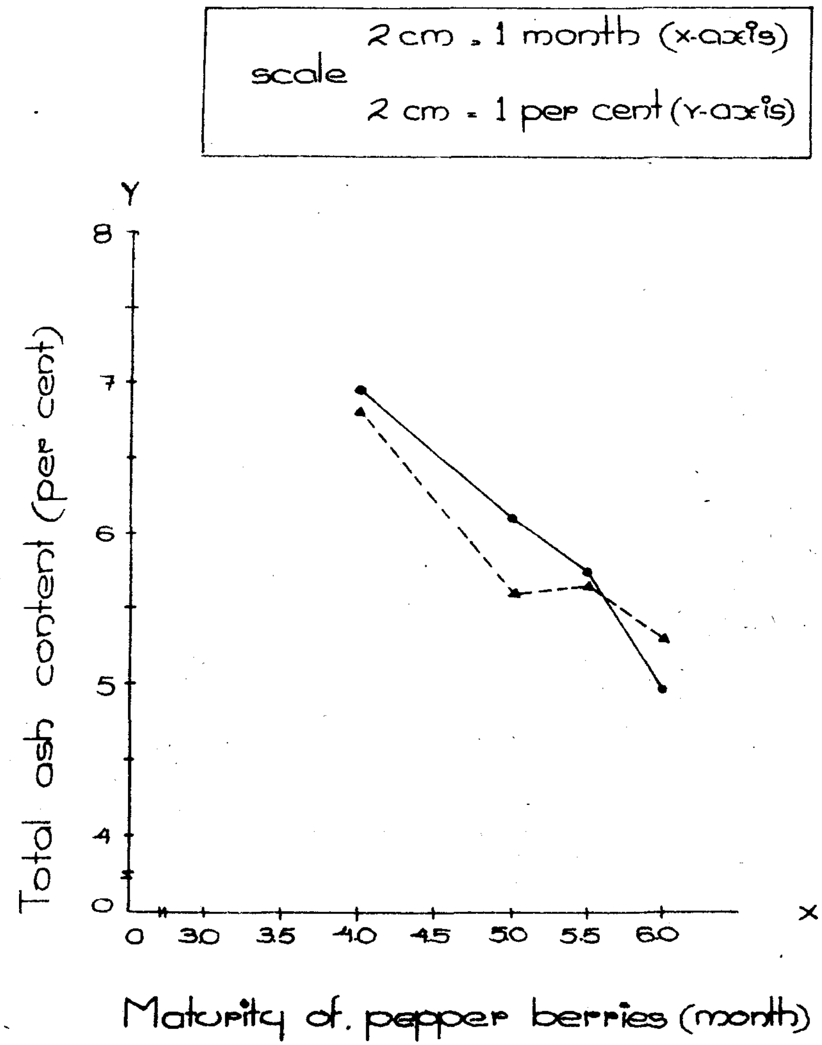


Fig.7b- Total ash in the dehydrated green pepper berries

4.4.8.2. Acid insoluble ash

The acid insoluble ash content in fresh and processed berries are depicted in Table 13 and Fig. 8 a and 8 b.

Table 13. Acid insoluble ash content in fresh and processed pepper berries at different harvest stages.

Stages of harvest.	Percentage of Acid insoluble ash on dry weight basis.			
	Karimunda		Panniyoor-I	
	Fresh	Processed	Fresh	Processed
(1)	(2)	(3)	(4)	(5)
I	0.57	-	0.61	-
II	0.62	0.64	0.67	0.69
III	0.72	0.76	0.74	0.74
IV	0.78	0.78	0.81	0.85
V	0.86	0.91	0.85	0.89

The accumulation pattern of acid insoluble ash showed an increasing tendency in both the cultivars as the maturity of the berries advanced.

In the processed berries the content of acid insoluble ash was slightly higher compared to that of fresh ones.

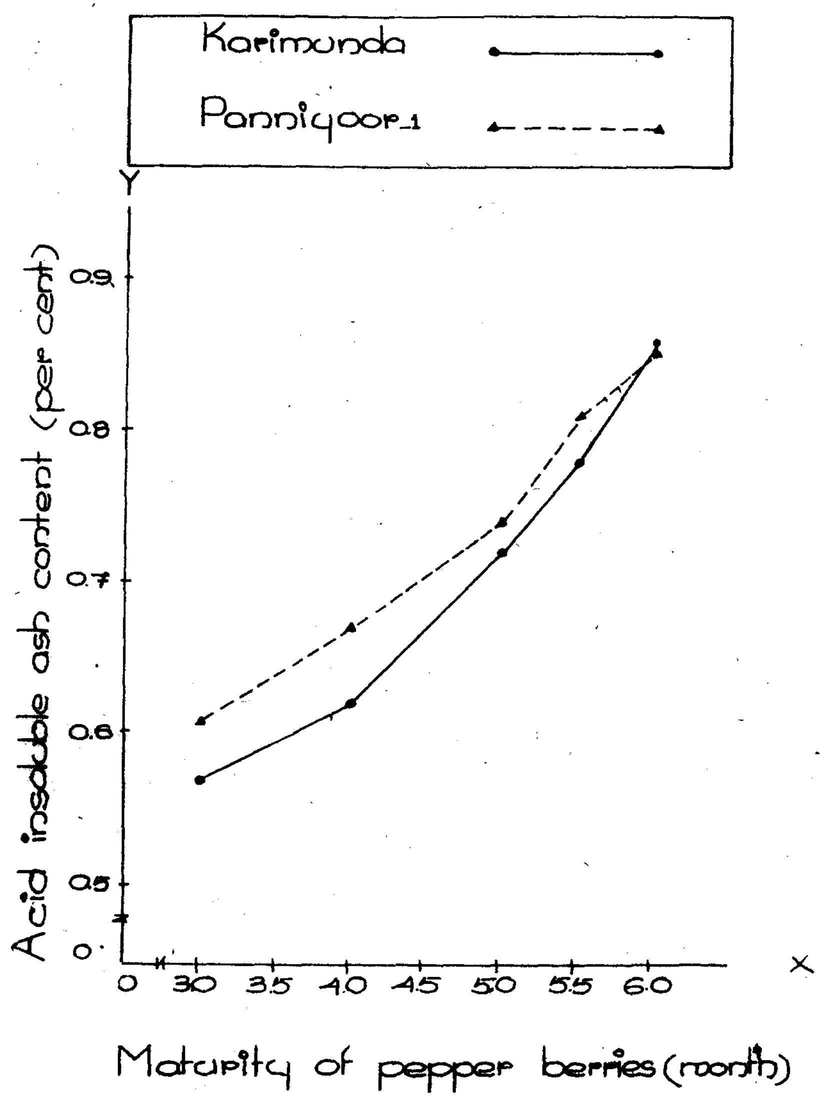


Fig.8a. Acid insoluble ash in fresh pepper berries. (dry weight basis).

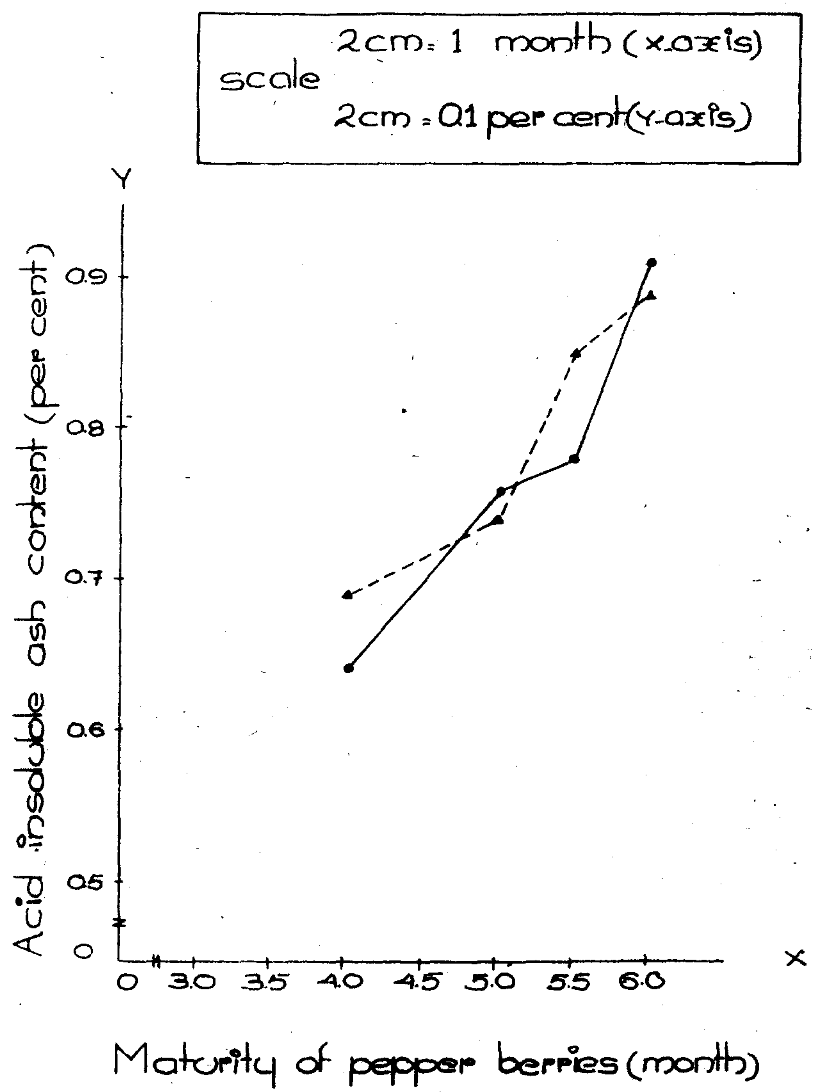


Fig.8b. Acid insoluble ash in the dehydrated green pepper berries.

4.5 Solar dehydration

The assessment of treatments using filtered lights with different coloured glasses is presented in Table 14.

Table 14. Assessment of processed materials under solar dehydration.

Colour of Solar chamber.	Wave length of light (nm)	Extent of green colour retention.	Organoleptic characters.		
			Colour	Appearance.	Texture
(1)	(2)	(3)	(4)	(5)	(6)
1. Direct sunlight	-	Poor	Bleached fully	Unsatisfactory.	Medium
2. Filtered sunlight through					
(i) White glass	575	Poor	Bleached lightly	Unsatisfactory.	Coarse
(ii) Blue glass	730	Scattered light-green patches.	Dim with light green patches	Unsatisfactory.	Coarse
(iii) Green glass	685			Unsatisfactory	Coarse
(iv) Amber glass	665			Unsatisfactory.	Coarse

Solar dehydration of produces of different treatment combinations did not yield satisfactory results in any of the harvest stages. However, there was variation in the time required for dehydration. It was 15 to 20 hours under direct sun and 25 to 35 hours under filtered light. The difference in the wave length of light allowed to pass through has not affected the drying period.

The data indicated that the berries dehydrated in the open sun were completely bleached in appearance. The produce obtained from the filter glass chambers had patches of green colour. Neither their appearance or texture was satisfactory. The distinction between the dehydrated material from the different filter chambers was also not clear.

4.6. Dehydration and rehydration ratios

The recovery of dehydrated material with reference to time of blanching for different harvest stages are given in Table 15 a and Fig. 9 a.

Table 15 a. Percentage recovery of dehydrated pepper under varying blanching durations from different harvest stages.

(Data underlined indicate the best treatment)

Duration of blanching (Minutes)	Stages of harvest	II		III		IV		V	
	Cultivar	K	P	K	P	K	P	K	P
0		21.60	21.70	27.10	27.55	30.2	31.6	36.4	37.20
10.0		<u>18.90</u>	<u>17.20</u>	24.30	24.00	28.1	29.0	34.2	35.10
12.5		16.90	16.10	<u>20.73</u>	<u>20.20</u>	27.0	28.9	33.0	34.70
15.0		12.30	12.10	18.30	18.25	<u>27.0</u>	<u>28.64</u>	<u>33.80</u>	<u>34.20</u>

K - Karimunda

P - Panniyoor-1

The data revealed that the recovery of the dehydrated material was inversely proportional to blanching time that too depending on the maturity of the berries. The drain solution obtained after blanching was found to possess deeper brown colour which again was related to duration of blanching. With increased blanching time, the drain solution became more and more deeper especially of produces of early harvests.

Rehydration in water at 70 °C was found more efficient taking only 30 to 50 minutes according to advancement in maturity for maximum effects, as against 5 to 8 hours at room temperature.

Rehydration in water at 70 °C also helped to wash off the sulphite residue adhering to the berries as visible from the rehydration media.

The extent of rehydration afforded by different treatments are presented in Table 15 b and Fig. 9 b.

Table 15 b. Rehydration rate per kg of dehydrated material in different treatments.

Stages of harvest	Cultivar	
	Karimunda	Panniyoor-I
(1)	(2)	(3)
II	5.00	5.60
III	4.10	4.05
IV	3.10	2.75
V	2.40	2.15

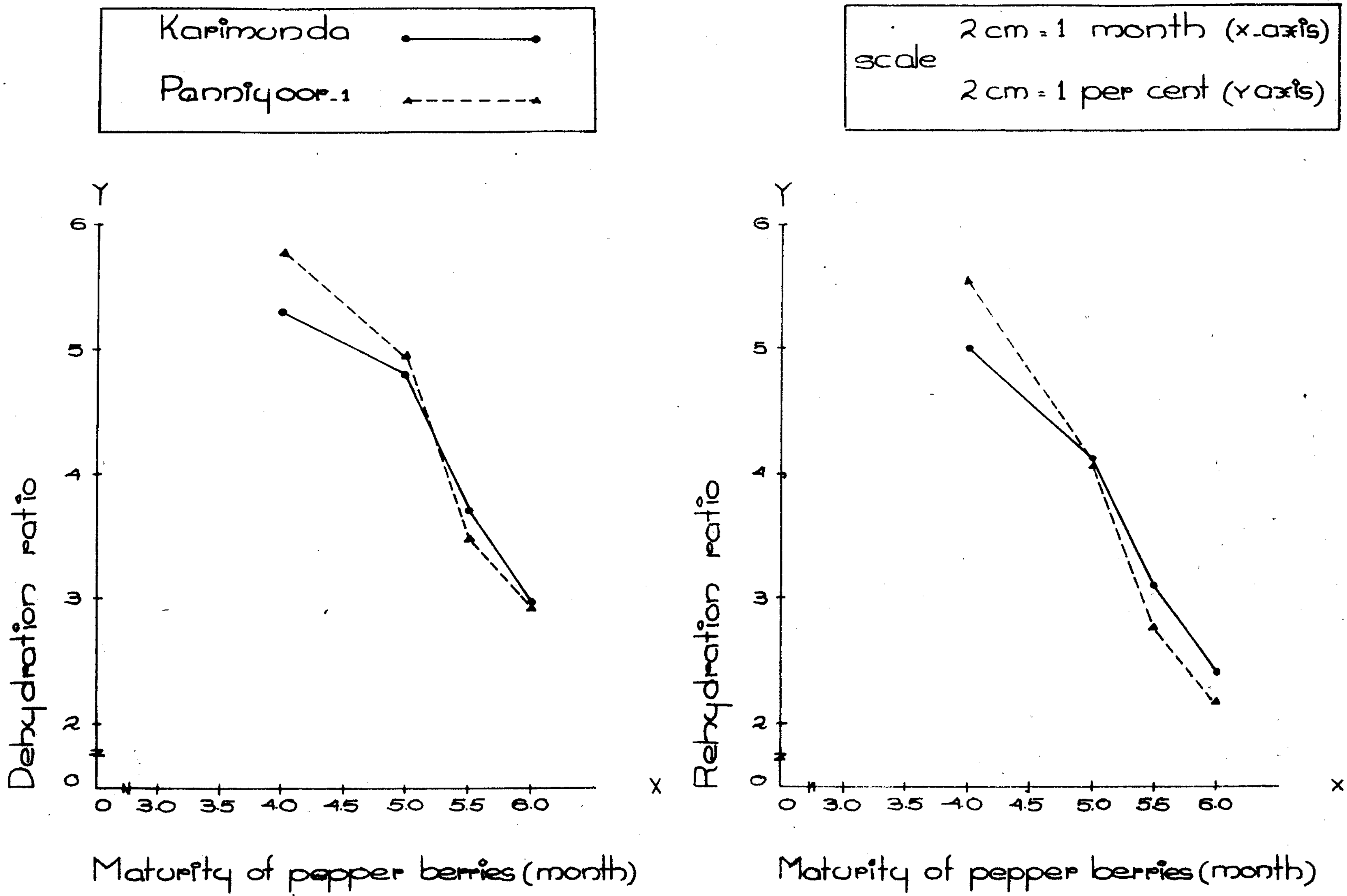


Fig. 9a - Dehydration ratio of processed pepper berries

Fig. 9b - Rehydration ratio of processed pepper berries

The data revealed that the rehydration efficiency decreased as the maturity of the berries advanced. In both the cultivars, the reduction was to a tune of 50% between IInd and Vth stages of harvest.

A comparison of dehydration and rehydration ratios of processed pepper berries of each cultivar is depicted in Fig. 10 a and 10 b.

4.7. Storage efficiency

The four storage methods tried were similar in protecting the dehydrated material from the ingress of moisture, loss of colour and other volatile substances for a period of three months, for which, they were observed.

The analysis of berries of different treatments for colour, volatile oil and ingress of moisture before and after storage did not reveal any variation.

4.8. Economics of processing techniques.

The loss in weight of berries during the process of preparation of dehydrated green pepper adopting different treatments was high compared to conventional preparation of black dry pepper. The extent of dehydration was less as the maturity stage advanced, the maximum dehydration being exhibited by immature berries. The data presented in Table 15 a also indicated that compared to processing of dry black pepper, a practice largely in vogue, more quantity of raw material would be required for the production of dehydrated green pepper.

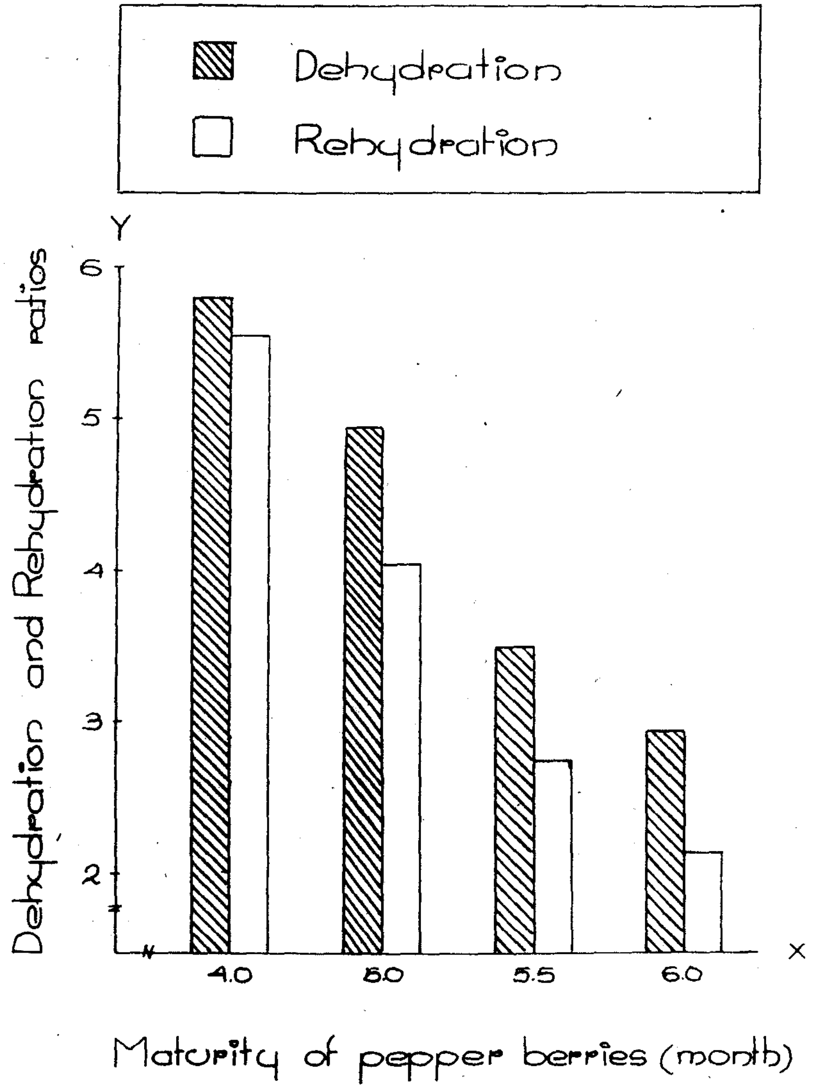


Fig.10a. Dehydration and Rehydration ratios of processed pepper berries - Panniyoor-1

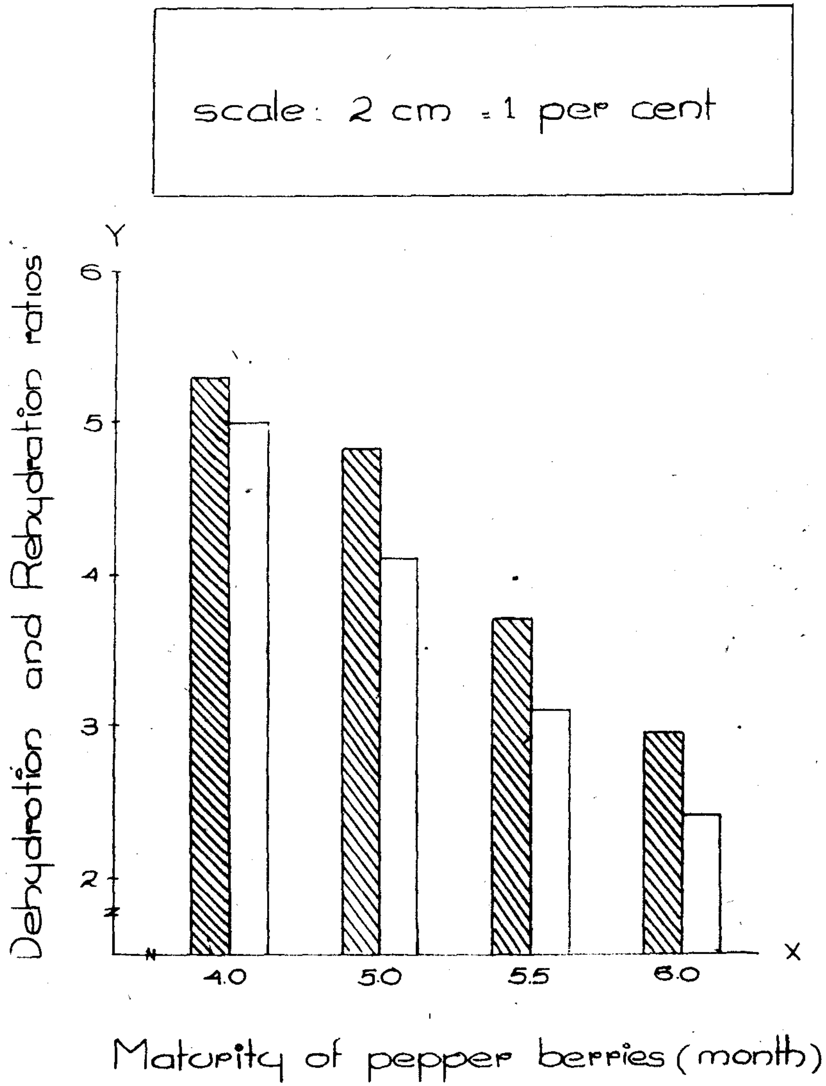


Fig.10b. Dehydration and Rehydration ratios of processed pepper berries - Karimunda

The quantity of fresh pepper berries at different stages of maturity required for the production of one kg dehydrated green pepper and the quantitative loss of produce accruing due to premature harvesting are presented in Table 16. Conversion factors worked out for different immature stages to nullify the loss in weight of berries accrued due to their immaturity are also presented.

Table 16. Quantitative relationship between immature and mature pepper berries. (Fresh weight basis)

Harvest stages.	Requirement for the production of one kg of the dehydrated product. (kg)		Quantity to be reckoned as equivalent to 100 kg berries of V stage (Mature) (kg)		Convertion factor - immature to mature berries (Vth stage)	
	Karimunda	Panniyoor-I	Karimunda	Panniyoor-I	Karimunda	Panniyoor-I
(1)	(2)	(3)	(4)	(5)	(6)	(7)
II	5.29	5.81	169	171	1.69	1.71
III	4.82	4.95	134	135	1.34	1.35
IV	3.70	3.50	121	118	1.21	1.18
V	2.96	2.93	100	100	1.0	1.0

The data indicated that the requirement of raw material for processing was on the decrease as the maturity of the berries advanced.

A comparison of data revealed that the requirement of raw material for dehydrated green pepper production continued to increase as the maturity level of berries decreased.

Compared to usage of 100 kg fresh material of Vth stage (mature) requirement of II, IIIrd and IVth stages would be 169 kg, 134 kg and 121 kg for Karimunda and 171 kg, 135 kg and 118 kg for Panniyoor-I respectively.

The cost of production of one kg of dehydrated green pepper under different maturity stages worked out are presented in Table 17.

Table 17. Cost of production per kg of dehydrated green pepper berries.

(Rs.)

Stage of harvest	Karimunda			Panniyoor I		
	Cost of green berries	Processing charges	Total	Cost of green berries	Processing charges.	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
II	44.70	26.45	71.15	49.68	29.05	78.73
III	32.29	24.10	56.39	33.41	24.75	58.61
IV	22.38	18.50	40.88	22.34	17.45	39.79
V	14.80	14.80	29.60	14.60	14.60	29.20

The data revealed that the production cost decreased as the maturity of the berries advanced. But the berries from the Vth stage of harvest (fully matured berries) were not suitable for dehydrated green pepper preparation.

The data on economics revealed that harvesting of berries 15 days prior to normal maturity (IVth stage) was most economical.

DISCUSSION

DISCUSSION

Black pepper (*Piper nigrum*, L.) is an important spice crop which accounts for about 35 per cent of the World trade in spices. Supermacy of pepper in the world trade of spices remains unchallenged.

The present commercial products of pepper are black and white forms, although attemps are underway to deversify the exports. The bulk and raw forms exported are reprocessed into other forms in the consuming countries according to their specific needs.

The trend prevalent in India to export diversified forms of processed pepper offers much scope provided the quality standards are ensured. One such commercially important product is dehydrated form of green pepper, which is said to be a delicacy enjoying premium price in the world trade. This product has the advantage of low cost of packing and transhipment compared to canned products. Recognising these aspects, investigation was undertaken in the College of Horticulture, Vellanikkara on the techniques for retention of green colour and other quality attributes in the processed berries of two important pepper cultivars of Kerala viz. Karimunda and Panniyoor-I and the results obtained are discussed in the following section.

5.1. Selection of green pepper berries

The recovery of well formed berries as evidenced by their uniformity in size and density held close relationship with their maturity stages. The recovery percentage gradually improved in both the cultivars as the maturity of the berries advanced. This can be attributed to the differential period in fruit set in pepper vines. Higher recovery percentage in the advanced harvest stages is also because of faster development of berries due to rapid accumulation of starch as revealed in this study which supported the earlier findings of Mitra et al. (1966), Mathai (1981) Mangalakumari (1983) and Ratnawatha and Lewis (1983).

5.2. Processing treatments

5.2.1. Kinetin

With regard to retention of green colour, kinetin treatment was not effective as the colour of the treated berries as well as those of control were similar. But, Singh (1980) reported that cytokinins helped to prevent the break down of chlorophyll. Hence, it could be presumed that in the present study the duration of dipping and concentration used might have been not adequate to assist colour retention in berries.

5.2.2. Blanching

Blanching helped retention of green colour in pepper berries. The effective blanching requirement was very specific depending on the maturity of berries. For berries of IInd stage, blanching for 10 minutes, IIIrd stage 12.5 minutes and IVth stage 15 minutes were found ideal. Berries of Vth stage failed to retain green colour with the blanching levels attempted, which indicated that berries beyond the IVth stage are not ideal for processing dehydrated green pepper. Blackening of pepper berries during drying was due to enzymatic oxidation of polyphenols in the berries (Mangalakumari et al.,1983). Retention of green colour by blanching treatments observed in the present study was due to prevention of enzymatic oxidation of phenolic compounds as reported by Lewis et al. (1976), Mathew and Sankarikutty (1977) and Nambudiri et al. (1978). Variation in the effective blanching requirement with reference to the harvest stages observed in the present study might be due to the changes in the distribution pattern of phenolic compound in berries of different maturity levels as reported by Mangalakumari et al. (1983).

5.2.2.1. Magnesium Sulphate

Alkaline media has been reported very efficient in green colour retention in peas (Blair and Ayres, 1962) in Cardamom, (Nararajan et al., 1968). In the present study blanching berries in a media containing magnesium sulphate was found effective in colour retention, the concentration varying according to maturity of berries. One per cent magnesium sulphate was required for berries of IInd harvest stage, which had to be increased to 2.5 per cent for berries of both IIIrd and IVth harvest stages. In the case of berries of Vth harvest stage, colour retention could not be observed even with five per cent magnesium sulphate. The chlorophyll degradation (substitution of magnesium ions in the chlorophyll molecules by the hydrogen ions), stood retarded by the presence of magnesium ions in the blanching media. This was attributed as the reason for the beneficial effect of magnesium sulphate on green colour retention in berries.

5.2.2.2. Ascorbic acid

In the present study, addition of 0.025 per cent ascrobic acid in blanching medium imparted better green colour to dehydrated pepper, which could be attributed to its antioxidative property. Similar result has been reported by Lease and Lease (1956 b) in Chillies.

5.2.3. Sulphite treatment

The sulphite treatment with sodium metabisulphite along with citric acid was found effective in colour retention after dehydration compared to the processed material of the control which possessed a blackish tinge. The better retention of green colour was due to efficiency exhibited by Sodium metabisulphite as a good inhibitor of phenols as reported by Mathew and Paripa (1971). Mangalakumari et al. (1983) had observed outward spreading of phenolic extractives along with moisture during the process of dehydration, which she found as responsible for imparting blackish colour to dehydrated berries devoid of any treatment. The post blanching dip in the sulphite solution helped to wash away the adhering phenolic compound besides providing a protective covering on the berries, which reduced the possible blackening of the berries. Citric acid retarded the possible oxidative process in storage, as reported by Natarajan et al. (1969) in chilli.

5.2.4. Mechanical dehydration

Dehydration of berries utilizing 'Cross-flow Air Oven' was found superior than 'Cabinet Drier'. The superiority of 'Cross-flow Air Oven' can be attributed to its efficiency in expelling the humid air accumulated during the process of dehydration. Similar result was reported by Purseglove et al. (1981 b) in turmeric.

Regarding temperature requirements, it was found that an initial temperature of 70 °C during the first hour, followed by 50 °C as ideal. These findings were similar to those reported by Purseglove et al. (1981 b) in cardamom, they have found the necessity for the maintenance of a higher temperature in the initial phase.

5.3. Evaluation of treatment combinations

Success in any method of processing dehydrated green pepper would depend on the efficiency with which the enzymatic oxidation is arrested and also the protection afforded to chlorophyll from degradation. Therefore, to assess the efficacy of different treatment combinations as depicted by the expression of green colour, evaluation for organoleptic characters was done in the study.

5.3.1. Organoleptic characters

Study on organoleptic characters viz. colour, appearance and texture of the samples revealed that the berries of IInd, IIIrd and IVth harvest stages were better for processing as dehydrated green pepper. Karimunda, was found better than Panniyoor-I in green colour retention because of its higher chlorophyll content in the berries. For berries of Vth harvest stage, the techniques tried were not efficient presumably due to the fact that as the berries tended to attain full maturity, degradation of chlorophyll or pigment conversion would have set in as postulated by Woolhouse (1967) and Leopold and Kriedemann (1981). The results, thus indicated, that maturity of berries at harvesting time was an important factor to be reckoned for the successful preparation of quality dehydrated green pepper.

5.3.2. Identification of best treatment combination

The processing requirements were found to vary according to harvest stages. Hence, the best combination among the treatments tried was identified for each stage of harvest by organoleptic tests. The possible reasons have already been described under section 5.2.

5.4. Quality evaluation of fresh and processed pepper berries.

The chemical constituents in the pepper berries showed fluctuating trend during the period of development. The same trend was seen reflected in the berries processed from them. As the production of dehydrated green pepper is mainly intended for foreign markets, quality attributes other than organoleptic characters also assume importance as pointed out by Natarajan (1981).

5.4.1. Moisture

The moisture content in fresh berries exhibited a decreasing trend as the maturity advanced. Accordingly, the dry weight of berries continued to increase from earlier phase to final phase of development. The decrease in the moisture content of berries during advanced maturity is attributed to the faster accumulation of starch as reported by Mathai (1981) and Ratnawatha and Lewis (1983).

Dehydration of produce to a safer moisture level is imperative for safe storage and colour retention as most of them are hygroscopic (Pruthi, 1980). In a dehydrated product, a moisture percentage above 12 was deleterious causing mould attack besides colour reversion (CFTRI, 1963). For dehydrated green pepper, ISI(1980) has stipulated the maximum moisture percentage for storage as eight. In the present study, it was found that under Vellanikkara conditions, product with 10 per cent moisture had a shelf life for three months.

5.4.2. Chlorophyll

There was gradual reduction in chlorophyll content as the maturity of berries advanced. The reduction in the chlorophyll content of berries towards maturity is attributed to the deterioration of chloroplast as suggested by Woolhouse (1967) and due to disintegration or convertion of chlorophyll pigments as indicated by Leopold and Kriedemann (1981).

Retention of maximum chlorophyll is an important attribute for dehydrated green pepper. Blanching at boiling point resulted in loss of green colour in spinach (Cruess ,1958). But the present study revealed that careful blanching avoiding boiling minimised the distortion of chlorophyll tissues ensuring better retention of green colour.

5.4.3. Volatile oil

The trend in volatile oil content in berries of different maturities did not show consistency. In general, there was an upward trend in its content upto IInd stage followed by a decline till the Vth stage in both the cultivars, similar to the observations of Purseglove *et al*. (1981 a). They have postulated that the maximum accumulation of volatile oil in berries of Indian cultivars was at 4½ months maturity, which decreased thereafter. The reduction in the volatile oil content in the advanced stages of development of berries was due to increase in starch content diluting this flavour principle as found by Ratnawatha and Lewis (1983).

The loss of volatile oil due to processing was maximum in immature berries. As the berries advanced in maturity, reduction in the loss of volatile oil could be observed. Higher percentage loss of volatile oil due to blanching can be attributed to the location of essential oil cells in the inner part of the outer skin of the berries as reported by Hardman (1972) and Mangalakumari(1983). The qualitative changes occurring to the components due to blanching treatment were not studied, but they deserve detailed investigation, as Pruthi *et al*. (1976) have reported wide variation in aroma constituents as a result of blanching treatment.

5.4.4. Piperine

In Karimunda, maximum piperine content was noticed at the IIIrd stage, while in Panniyoor-I, it was at the IInd stage. In Panniyoor-I, the piperine content was comparatively low. Poulose (1973 a) also found similar variation and rated Panniyoor-I as a medium pungent variety. According to Purseglove et al. (1981 a), the piperine content continued to increase even after maximum accumulation of volatile oil in the berries. The present study also gave concordant results. The reduction in piperine content towards maturity of berries was due to rapid increase in starch content which diluted the pungent principles (Ratnawatha and Lewis, 1983). The contents of piperine in the processed materials of different harvest stages were slightly more than that of raw berries, except in the IInd stage of harvest, wherein the piperine content was lesser than that of raw berries of the corresponding stage of harvest. Karimunda possessed higher piperine content in the processed forms also. Comparison of harvest stages indicated that berries at IIIrd stage contained maximum piperine in the processed material.

The better retention of piperine in the berries was due to the location of piperine cells in the inner core of the pepper berries (Mangalakumari, 1983), its water insoluble nature (Sumathikutty et al., 1981) and its ability to sublimate only at 104 °C (Janot and Chaignean, 1947).

The higher piperine content observed in processed product compared to raw forms can be attributed to the loss of other constituents during processing.

5.4.5. Nonvolatile ether extract (NVEE)

In both the cultivars, maximum NVEE could be observed in the berries of Ist harvest stage and it got reduced as the maturity of berries advanced. In the present study, NVEE exhibited a better retention compared to volatile oil. The results obtained were similar to those published by Pruthi et al. (1976). The water insoluble alkaloids, which sublime only at very high temperature, form the major part of NVEE (Jose, 1978). The better retention of the NVEE in the processed materials can be attributed to this fact. In the present study, it was found that there was only partial loss of NVEE, which corroborated the findings of Pruthi et al. (1976).

5.4.6. Starch

The starch content showed an increasing trend towards maturity in both the cultivars contrary to the pattern noticed in respect of other major constituents. The increase of starch content was gradual till the IIIrd stage and thereafter rapid. The trend in starch content was found inversely proportional to crude fibre content as already reported by Mitra et al. (1966), Govindarajan (1977) Jose (1978) and Mathai (1981).

There was no appreciable loss of starch due to processing treatments. This was due to insolubility of starch in water and no distortion to granules when blanched as they remained enclosed in sheaths (Mangalakumari , 1983).

5.4.7. Crude fibre

The crude fibre content decreased as the maturity of berries advanced. The reduction in the crude fibre content proportionate to maturity of berries has been reported by Pruthi et al. (1976), Sumathikutty et al. (1979) and Mathai (1981). The sudden fall in the crude fibre content in the earlier stages of berry development followed a rise in the contents of volatile oil and piperine during the first half of berry development and rise in starch content in the second half in both the cultivars. These observations are also quite similar to the findings of Mathai (1981). The reason for less concentration of crude fibre can also be attributed to the significant increase in starch content as Sumathikutty *et al*. (1979) reported synthesis of fibre till maturity. In the processing treatment the crude fibre content remained unchanged.

5.4.8. Ash

The accumulation pattern of total ash was quite similar to that of crude fibre in both the cultivars. The peak accumulation was at the IInd stage in Karimunda and at the Ist stage in Panniyoor I. The accumulation declined thereafter in both cultivars.

The acid insoluble ash content increased with maturity of the berries. In the processed berries, ash content was on par with that of fresh berries.

5.5. Solar dehydration

The present study using different coloured glasses allowing filtered light of wave length beyond the range of 600-650 nm revealed that none of them was successful in helping green colour retention in pepper berries. However, Narayanan (1983) observed better colour retention in pepper berries by using light cutting wavelength of the range of 600-650 nm. The failure in colour retention in the present study may be due to prolonged period taken for dehydration.

5.6. Dehydration and rehydration ratios

The data revealed that the extent of dehydration was closely related to the duration of blanching as loss of constituents occurred due to prolonged blanching. The colour of the drain solution was indicative of this, more colour and high viscocity, indicating excess loss of constituents. In the processing treatment adopted careful blanching, avoiding boiling helped to minimise this loss to a great extent besides arresting destortion of tissues which gave presentable appearance to the finished product. The reduction in the weight of the dehydrated material observed in the study can be attributed to the loss of volatile substances in the process of blanching as has been indicated by Pruthi <u>et al</u>. (1976).

Rehydration was quicker with water at 70 °C compared to water at room temperature (30 °C). The variation was so great, that while satisfactory rehydration could be achieved with water at 70 °C in 30 to 50 minutes, the time required was as high as 3 to 5 hours with water at room temperature.

Presence of sulphite residue in the finished product is an undesirable feature (Govindarajan, 1981). Usage of water at higher temperature also helped to wash off the sulphite coating of processed material, the extent of which has not been estimated.

The efficiency of rehydration was related to stage of harvest, maximum rehydration rate being accounted in stage II and the values decreased according to the ascending order of the stages. Between cultivars, the variation in this respect was not very much perceptible. The minimum efficiency in rehydration exhibited by Vth stage is attributed to reduced crude fibre and high starch contents in the advanced stage of development of berries.

5.7. Storage of processed material

All the four storage methods tested were equally efficient for a period of three months upto which studied. However, it is worthwhile to study the efficiency of storage techniques for a longer period as the produce is intended mostly for overseas shipment.

5. 8. Economics of processing techniques.

The trade in pepper is at present oriented towards preparation of dry black pepper using solar dehydration of fully matured berries. Compared to the recovery efficiency of this product, loss in weight was inevitable when processed into dehydrated green pepper. Further, the intensity of loss was more when raw material of immature stages were used. But for successful production of dehydrated green pepper, fully matured berries were not so ideal from the point of view of colour retention which is a most important attribute for dehydrated green pepper. Considering the above aspect, more quantity of raw material will be required for processing dehydrated green pepper. The cost of production of dehydrated green pepper will also be higher than that of black pepper, the factors contributing for the same being excess raw material and processing charges. These aspects call for safe guarding the interest of the cultivators through awarding premium price as they will be interested to harvest the produce at an early stage which will be at the expense of its weight. Payment of premium price is worthwhile also as dehydrated green pepper enjoys higher price than black pepper. From the quality point of view also, dehydrated green pepper is in no way inferior to black pepper except for its starch content which is of little significance so far as this spice is concerned.

Among the pepper cultivars studied the data were in favour of Karimunda than Panniyoor-I, although whose produce was also of acceptable quality. Screening of other important cultivars for their suitability for dehydrated green pepper production is one of the future line of work suggested.

SUMMARY

SUMMARY

Investigation was carried out at the College of Horticulture, Vellanikkara during 1983-84 for the 'Standardisation of techniques for retention of green colour in processed pepper'. The results obtained are summarised below:

1. The percentage of recovery of pepper berries suitable for processing gradually increased in both the cultivars as the maturity of the berries advanced.

2. Blanching helped in green colour retention on pepper berries. However effective blanching requirement varied with maturity. Kinetin treatments were not effective in colour retention. Magnesium sulphate and ascorbic acid used in the blanching media and citric acid and sodium metabisulphite in the post blanching media were effective in this regard, the concentrations varied according to the maturity of berries.

3. The chemical constituents in the pepper berries showed fluctuating trend during their period of development. Moisture, chlorophyll, volatile oil,piperine, nonvolatile ether extract, crude fibre and total ash exhibited a declining trend, while starch and acid insoluble ash showed an increasing trend as the maturity of the

berries advanced. There was loss of chlorophyll, volatile oil and nonvolatile ether extract during processing while other constituents were not affected appreciably by the processing treatments.

4. Harvesting berries at IVth stage (5½ months maturity) was found ideal for the processing into dehydrated green pepper. This harvest stage proved to be economical and the produce of which possessed desirable extent of pungent and aromatic principles. The starch content was also low and fibre content high at this maturity level.

5. Karimunda was found superior with regard to chlorophyll, volatile oil, piperine content and in green colour retention after processing compared to Panniyoor-I, the produce of which was also of acceptable quality.

6. Solar dehydration under direct sun and filtered light did not help to retain the green colour in the processed material and the results were in favour of mechanical dehydration with Cross-flow Air Oven.

7. The recovery of dehydrated material increased with maturity of berries. Rehydration was quicker with water at 70 °C. The extent of rehydration decreased with maturity.

8. The processed material of 10 per cent moisture could be successfully stored for three months under all the four methods tried.

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STANDARDISATION OF TECHNIQUES FOR RETENTION OF GREEN COLOUR IN PROCESSED PEPPER (*Piper nigrum*, Linn.)

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ABSTRACT OF A THESIS

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ABSTRACT

Investigation was carried out at the College of Horticulture, Vellanikkara, during 1983-84, to standardise techniques for retention of green colour in processed pepper by adopting treatments of kinetin (10, 20 ppm), magnesium sulphate (1, 2.5, 5%), ascorbic acid (0.025, 0.05%), citric acid (0.05%), sodium metabisulphite (1% SO_2) and blanching (10, 12.5, 15 minutes). Mechanical and solar dehydration methods were also compared.

The study revealed that improvement of the blanching media through addition of magnesium sulphate inducing an alkaline condition was desirable. Antioxidants such as ascorbic acid and citric acid were effective in improving green colour retention in berries through retardation of oxidative process responsible for blackening of berries in the dehydration process. The phenolic inhibitor, sodium metabisulphite was also effective in this regard. But kinetin was not found effective. Among the dehydration methods, mechanical dehydration that too Cross-Flow Air Oven method was superior.

All the chemical constituents in pepper berries studied, showed a fluctuating trend during the period of development. Except chlorophyll volatile oil and nonvolatile ether extract no other constituents suffered loss during processing. The processed produce of 10% moisture could be successfully stored for three months under Vellanikkara condition. Harvesting spikes at 5½ months maturity for the preparation of dehydrated green pepper proved to be economical. Among pepper cultivars studied, the data were in favour of Karimunda than Panniyoor-I, whose produce was also of acceptable quality.