QUALITY AND FATTY ACID COMPOSITION OF COCONUT OIL IN RELATION TO VARIETAL VARIATION AND MINERAL NUTRITION

BY

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THESIS

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1994

DECLARATION

I hereby declare that this thesis entitled "Quality and fatty acid composition of coconut oil in relation to varietal variation and mineral nutrition" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Quality and fatty acid composition of coconut oil in relation to varietal variation and mineral nutrition" is a record of research work done independently by Smt. V.S. Geetha Kumari, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

INTRODUCTION

Coconut palm is a versatile crop plant which ranks first among the tropical palms in respect of cultivated area and oil yield. It is both an agricultural and industrial crop with immense economic importance. Coconut is one of the important source of edible oil having maximum oil yield (average 65%) from the dried kernel. As an oil seed it caters to the needs of the country particularly South India, for edible oil and as a food, it enjoys a unique status in Indian culinary. Coconut oil is the only edible oil with a high content of short chain and medium chain fatty acids like lauric and myristic acids and therefore, is different in chemical composition from other vegetable oils produced at present in India. Products derived from coconut oil, coconut meat, coconut water, coconut milk, copra and dessicated coconut find numerous applications in many agro industries. Among the fruit and plantation crops, coconut is aptly termed as the "Kalpavriksha" in Kerala, the tree which provides food, fuel, shelter and drink for human beings as well as raw materials for many industries. India is the third largest producer of coconut in the world with an area of 1.2 million hectare and an annual production of about 7000 million nuts.

As Kerala occupies a pivotal position with regard to antiquity, area and production of coconut in India, detailed investigation on the clinical and nutritional aspects of coconut oil will be of immense help to develop new varieties for this perennial tree crop in addition to its contribution to the theoretical corpus of lipidology. While considerable attention has been paid by research workers on the effect of mineral nutrition and variety on the yield of copra and oil, information regarding their effect on quality parameters and fatty acid composition is still fragmentary and inadequate (Arnon, 1977).

Coconut oil accounts to about 4.9% of the world production of fats and oils and assumes much importance among the common tropical vegetable oils in the world. When other vegetable oils like palm oil, soyabean oil, groundnut oil, safflower oil, sunflower oil, gingelly oil, mustard oil, cotton seed oil etc., appeared in the world market, coconut oil was pushed back with the alleged reason that it is hypercholesterolemic, thus increasing the risk of artherosclerosis. But recent studies on the lipid biochemistry of dietary fats reveal that hypercholesterolemic condition depends mainly on hereditary traits of individuals and fatty acid chain length.

The quantity and quality of edible oils are extremely important considerations in cultivar development because of the use of a variety of edible oils with varying dietary qualities. Although many studies have highlighted the effect of fertilizers and variety on the yield of coconut, work done to assess these effects on quality aspects and fatty acid composition of the oil is scanty and meagre. The extent of genetic variability in the fatty acid composition of different varieties of coconut is thus a hitherto unstudied aspect of biochemical research. Further there are very few convincing experimental results to study the effect of fertilization on oil composition. The consumption of large amounts of saturated fats especially of the short chain nature is having a pivotal role in the cholesterol metabolism of human beings. Considering the afore mentioned facts in view, it was felt essential to investigate the genetic variability among coconut palms in relation to oil quality, fatty acid composition and mineral nutrition. Thus the main objectives of the present investigation are summarised as follows:-

1. To study the effect of varietal variation on the oil content, quality parameters and fatty acid composition of coconut oil.

2. To study the effect of mineral nutrition on the oil content, quality parameters and fatty acid composition of coconut oil.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Coconut is an important tropical oil yielding palm with an oil yield of 65% of copra. There is a dire need to improve the productivity of coconut at present, to counteract the efforts to import edible oil and to meet the ever increasing domestic needs. A variety of edible oils are available in the market today with varying quality parameters and nutritional charateristics. Assesment of the quality parameters and fixing standards for the nutritional aspects are to be considered with top priority for the development of new varieties/cultivars along with the yield attributes.

Although many studies have addressed the effect of fertilizers and variety on the yield of copra and its content, work done to study the effect on quality aspects and fatty acid composition of well known coconut cultivars are scanty and meagre. The composition and quality of oil seeds vary with respect to genotype, seasonal variation, location and nutritional status (Nagaraj, 1990). Thus it is imperative to study the effect of genetic variability on the fatty acid composition of the oil, so that modifications could be made for tailoring varieties with desirable fatty acid composition and oil content. Further identification of such cultivars could aid in the breeding programmes also for future genetic improvement. An exhaustive review of available literature on the effect of variety and mineral nutrition on the oil content and quality parameters of coconut and other major oil seeds are summarised below.

2.1 Effect of varietal variation

2.1.1 Varietal variation and oil content

Romney (1972) in a Coconut Nutritional Survey carried out in Jamaica reported clear difference among the varieties of coconut in oil content.

Romney (1972) observed that the oil content of copra varied more between coconut varieties than between different environments. However, the differences between Jamaica Tall and Malayan Dwarf necessitated grading on the basis of oil content.

Out of the ten cultivars studied by Reddy et al. (1979), West Coast Tall gave the highest percentage of oil in the dried kernel (77%).

Reddy et al. (1980) in a study on the oil content of eleven coconut cultivars, reported the highest amount of oil in Laccadive ordinary (70.8%) followed by Laccadive small.

Louis and Ramachandran (1981) reported that tall varieties in general, recorded high oil content with few exceptions. Oil content in the hybrid were medium and it was closer to female parents. The dwarf varieties with leathery copra, possessed comparatively good percentage of oil.

Rao and Srinivas (1981) found variation in the oil content ranging from 64.7 -70.9% among nine varieties of coconut. Rajamony <u>et al.</u> (1983) also reported slight variations in the oil content among fifteen coconut hybrids. They found that the maximum recovery of 67.11% was from West Coast Tall x Gangabondam.

Nambiar and Prasada Rao (1988) observed varietal variation in the oil content among five coconut cultivars. Laccadive Ordinary recorded the maximum oil content of 73.3% followed by West Coast Tall (70.1%). The oil content in all the hybrids was intermediary to that of the parents.

Varietal variation in the oil content has been reported by many workers in different varieties of other oil seed crops like sesamum (Nagaraj, 1991), sunflower (Vasishta <u>et al.</u> (1992) and in Indian mustard (Krishna and Singh, 1992).

2.1.2. Varietal variation and oil quality

With the advent of modern cultivation and management practices adopted in recent years for coconut, farmers have achieved a substantial improvement in the total production and productivity of copra and oil. In addition to better agronomic practices, genetic improvement through concerted efforts made by plant geneticists also have contributed to variations in yield and yield parameters. Thus there exist large number of coconut varieties/cultivars including hybrids with distinct variability in yield attributes as well as quality parameters. As many of the differences in quality aspects are polgenecally controlled characters, genetic variability is also one of the aspects that could be exploited for selecting hybrids/cultivars with desirable quality parameters. A brief review of the above aspect is summarised here under.

Hardon (1968) reported varietal variation in oil quality among oil palms. Variety Elaeis oleifera carried more unsaturated fatty acid than Elaeis guineensis and the cross between these two carried unsaturated fatty acid intermediary of their parents.

Kartha (1972) reported varietal variation in the component fatty acids in coconut oil. Similar results has been reported by Kaunitz (1972) particularly in the chain length of fatty acids in coconut oil.

Gascon and Wuidart (1975) reported marked variability in the fatty acid composition of the original and their crosses of Elaeis guineensis. La Me x Deli hybrids had higher contents of unsaturated fatty acids.

According to NG et al. (1976) significant differences existed among the fruit of Elaeis guineensis for all fatty acids. Types 'pisifera' and 'albescens' appeared to have less palmitic acid and more linoleic acid than those of the other fruit types.

According to Noiret and Wuidart (1976) varietal variation existed in the fatty acid composition of palm oil. Among the parental origins, La Me appeared to be the best with high oleic acid and polyunsaturated fatty acid content and showed good variation among the different fatty acids. Deli x La Me and Deli x Yangambi hybrids were intermediary between the parental origins.

Significant varietal variation in the fatty acid composition of mesocarp oil of oil palm was reported by Hartley (1977). Elaeis oleifera oil had an iodine value of 78-88 much higher than that of Elaeis guineensis indicating a higher percentage of oleic and linoleic acid and a lower percentage of palmitic and other saturated acids. He also found that the hybrid of Elaeis guineensis and Elaeis oleifera contained lesser amount of unsaturated fatty acid when compared to Elaeis oleifera.

Ochs and Ollagnier (1977) observed no significant variation in the oleic acid content and iodine value among varieties, Dabour and Ivory Coast of oil palm.

Banzon and Resurreccion (1979) observed no significant variation in the fatty acid composition of the oil samples derived from four cultivars of Philippine coconut.

Rao and Srinivasa (1981) reported varietal variation among the component fatty acids in coconut. The range of variation between the varieties for the component fatty acids were 2.7 -10%, 5.8 -8.8%, 39.1 -62.1% and 13.4 -24.6% for Caprylic, Capric, Lauric and Myristic acid respectively.

Ollagnier and Olivin (1984) found high variation in the unsaturated fatty acid content in oil from Eleais guineensis and Elaeis melanacocca.

Majnu and Sjafrul (1984) reported variation in the fatty acid composition of palm oil from Elaeis guineensis, Elaeis oleifera and the hybrid Elaeis guineensis x Elaeis oleifera. Saturated fatty acid percent decreased and unsaturated fatty acid percent increased from Elaeis guineensis to Elaeis oleifera through their hybrid with mean oleic acid content of 33.8, 39.1 and 59.1%; linoleic acid content of 11.3, 11.4 and 16% and palmitic content of 48.2, 44.2 and 19.5% respectively.

Goh and Timms (1987) in a study on palm oil and palm kernel oil from Elaeis oleifera x Elaeis guineensis hybrid found that the mesocarp oil of the hybrid had a higher iodine value and a lower saponification value than Elaeis guineensis kernel oil. It was higher in myristic acid, lower in lauric acid and somewhat higher in unsaturated fatty acids.

Varietal variation in the fatty acid composition has been reported in other oil seed crops like groundnut (Branch et al. 1990), mustard (Khan et al. 1990) sesamum (Nagaraj, 1991) and sunflower (Vasishta et al. 1992) also.

2.2 Effect of mineral nutrition

2.2.1 Mineral nutrition and oil content

A review of studies conducted revealed that fertilizers greatly increased the yield of primary products without noticeable effect on the oil content (Ochs and Ollagnier, 1977).

Menon and Pandalai (1958) reported that nitrogen, phosphorus and potassium had no effect on the oil content of copra. Similar result has been reported by Muliyar and Nelliat (1971) in coconut due to different fertilizer treatments.

Romney (1972) observed no significant effect on nitrogen, phosphorus and potassium on the oil content of Jamaica tall variety of coconut due to different fertilizer treatments.

Appelqvist (1977) studied the oil content of some major oil seeds like groundnut, soyabean, sunflower, rape seed and cotton seed. He observed that nitrogen fertilization generally decreased the oil content, phosphorus often increased the oil content and potassium sometimes increased the same in oil seeds.

Zhao et al. (1991) observed a decrease in the oil content of rape seed due to increased fertilizer doses.

Nagre et al. (1991) reported a significant increase in the oil content of soyabean with increasing level of fertilizers.

2.2.1.1 Effect of nitrogen

A non significant effect of nitrogen on the oil content in oil seeds has been reported in sunflower (Sathyanarayana et al. 1985) and in mustard (Prasad and Eshanullah, 1988).

A decrease in oil content by nitrogen application has been reported in groundnut (Dimitrov and Georgiev, 1976) and sunflower (Patil and Shah,1993).

An increase in the oil content by increased nitrogen application has been reported in oil seeds like safflower (Mane, 1983) and sunflower (Loubser and Grimbeek, 1985).

2.2.1.2 Effect of phosphorus

A non significant effect due to phosphorus application has been reported in the case of groundnut (Dimitrov and Georgiev, 1976), safflower (Mane, 1983), sunflower (Maheswarappa et al. 1985) and mustard (Saran and Gajendra, 1990) with respect to oil content.

An increase in the oil content by increased phosphorus application has also been reported in oil seeds like sunflower (Samui and Bhattacharya, 1987) and groundnut (Jain et al. 1990, Choudhery et al. 1991).

Pushpangadan (1985) reported the decrease in the oil percentage of coconut with all incremental doses of applied phosphorus. Similar result has been reported in groundnut by Nair and Sadanandan, (1981).

2.2.1.3. **Effect of Potassium**

Romney (1972) in a study on Jamaica tall variety of coconut consisting of four levels of potassium fertilizers including zero, reported no significant effect due to treatments on the oil content.

Ochs and Ollagnier (1977) in a study reported that potassium played the foremost role in the production of lipids in coconut followed by nitrogen, phosphorus and magnesium.

Ochs and Ollagnier (1977) found no effect of potassium on the oil content of copra which remain constant at about seventy two percent regardless of the treatment.

Ochs and Ollagnier (1977) observed a slight increase in the oil content of varieties, Dabour and Ivory Coast (oil palm) with application of 6 kg potassium chloride per tree.

Ochs and Ollagnier (1977) in an experiment conducted by I.R.H.O found a slight decrease in the oil content (0.4%) in peanut varieties.

An increase in the oil content with increasing potassium fertilization has also been reported in oil seeds like groundnut (Nair and Sadanandan, 1981) and soyabean (Gaydou and Arrivets, 1983).

Pushpangadan (1985) reported a significant positive effect of potassium on the oil content (in percent) of coconut at all levels.

2.2.1.4. Effect of Calcium and Magnesium

Subramanian et al. (1976) reported an increase in the oil content of groundnut with increasing magnesium levels.

According to Arjunan and Gopalakrishnan (1980) the highest level of calcium gave the lowest oil content in groundnut .

Ochs and Ollagnier (1977) observed no significant effect of magnesium on the oil content of copra. Similar result has been reported in sunflower also by many workers. (Muthuvel and Rajukkannu, 1983).

An increase in oil content by calcium and magnesium application has been reported by Csengeri and Kozak in 1986 in sunflower.

2.2.1.5. Effect of Sulphur

Southern (1969) reported that sulphur deficiency in coconut palms, produced rubbery copra with a very low oil content as low as 36% on dry weight basis. Similar result has been obtained in coconut by Cecil and Pillai (1976).

An increase in the oil content by sulphur application has been reported in oil seeds like groundnut (Kamala Thirumalaswamy et al. 1986) rape seed (Sinha et al. 1990) and mustard also by many workers (Saran and Gajendra, 1990).

2.2.1.6 Effect of nutrient interactions

Appelqvist (1977) found that P and K in combination increased the oil content of sunflower.

Pushpangadan (1985) observed that the main effect of NxK significantly influenced the oil content in coconuts.

According to Turkhede (1991) N and P combinations did not significantly influence the oil content over the control.

2.2.2 Mineral nutrition and oil quality

There are very few convincing experimental results on the effect of fertilizers on oil composition. The few experiments conducted revealed negligible variations in the oil composition due to fertilization.

Ochs (1977) reported variation in the fatty acid composition of palm oil due to mineral nutrition. The iodine value was found to be reduced by fertilization in palm oil.

Maniciot et al. (1980) found no difference in the oil composition of copra due to fertilizer application.

Variation in the fatty acid composition of oil due to mineral nutrition has also been reported in oil seed like soyabean (Gaydou and Arrivets, 1983) and rape seed (Zhao et al. 1991).

2.2.2.1. Effect of nitrogen

A non significant positive effect of nitrogen application on the fatty acid composition of oil has been reported in rape seed by many workers (Lammerink and Morice, 1970. and Forster, 1977).

Variation in fatty acid composition in Indian mustard by the application of higher doses of nitrogen has been reported by Dasgupta and Ghosh (1977).

Mohammad et al. (1985) found a decrease in the iodine value with increasing doses of nitrogen in mustard.

Narang and Singh (1985) however reported an increase in the iodine value of mustard oil due to higher nitrogen doses.

2.2.2.2. Effect of Phosphorus

Ochs and Ollagnier (1977) reported that oil palms receiving higher doses of phosphorus gave higher content of polyunsaturated fatty acids than the control.

++++ According to Devarajan et al. (1981), the iodine value showed a decrease and saponification value an increase with phosphorus application in groundnut.

Salama (1987) observed an increase in the stearic acid content of sunflower oil due to `P' applications.

2.2.2.3. Effect of Potassium

Kee (1973) reported that potassium application increased the content of oleic acid in oil palm thereby improving the oil quality.

Ochs and Ollagnier (1977) found that higher levels of potassium gave higher content of polyunsaturated fatty acids than control in oil palm.

However Potassium fertilization did not affect the fatty acid composition of sunflower oil (Ochs and Ollagnier, 1977, Pandev *et al.* 1981).

2.2.2.4. Effect of Sulphur

Cecil and Pillai (1976) observed that sulphur deficiency in coconut produced oil with a higher iodine value and a lower saponification value compared to oil from natural copra. Similar result has been obtained by Southern (1969) in coconut varieties.

Ramanathan and Ramanathan (1982) reported no significant change in the oil composition of groundnut due to sulphur application.

2.2.2.5. Effect of nutrient interactions

Ochs and Ollagnier (1977) reported higher iodine values for the oil obtained from palms receiving NP fertilizers in combination.

In an experiment to study the response of six mustard varieties to different combinations of N and P, Khan *et al.* (1990) reported minimum iodine value and maximum saponification value for the oil samples obtained from treatments $N_{60}P_{30}$ and $N_{60}P_{20}$ respectively.

MATERIALS AND METHODS

MATERIALS AND METHODS

Coconut is a perennial oil seed crop with a large number of cultivars having widely varying growth and yield characteristics. Informations regarding the effect of variety and mineral nutrition on the quality and fatty acid composition of coconut oil is fragmentary and inadequate (Arnon, 1977). The present investigation was undertaken to study the effect of varietal variation and mineral nutrition on the quality and fatty acid composition of coconut oil. Keeping this overall objective in view, samples were collected from different varieties/cultivars of coconut and analysed for their quality constants and fatty acid composition. In addition to this nut samples were also taken from an already ongoing experiment from the Coconut Research Station (CRS), Balaramapuram to study the effect of mineral nutrition on the quality parameters and fatty acid composition of the coconut oil. The programme of investigation thus planned was grouped into the following steps.

a. Collection of mature nuts from forty four well defined varieties/cultivars including hybrids of coconut from the Regional Agricultural Research Station (RARS), Pilicode and from the Instructional farm, Vellayani.

b. Collection of mature nuts from the ongoing 3^3 confounded factorial experiment with twenty seven treatments and two replications from the CRS, Balaramapuram.

c. Extraction of oil from copra by solvent extraction.

d. Determination of quality parameters like Acid value, Saponification value, Iodine value, Reichert-Meissel value and Polenske number of the oil samples.

e. Fractionation of the oil from selected varieties and treatments to quantify the constituent fatty acids.

f. Statistical analysis and interpretation of the data.

3.1 Collection of nuts

3.1.1. Collection of samples from the coconut germplasm

The Regional Agricultural Research Station of the KAU at Pilicode, with its collection of indigenous and exotic germplasm of coconuts planted at definite time intervals from 1924-25 onwards have been selected for the present investigation. The nuts were collected during the harvest season of September 1992, (28^{th} to 30^{th} September).

One nut each of uniform maturity was collected from two palms of the same age (as per records of the station) to represent a variety/ cultivar. In order to avoid seasonal variation , collection was done during 28th to 30 th September 1992 and hence only twenty four varieties/ cultivars could give two replications. In the case of the forty four varieties/ cultivars selected for the study, twenty of them were not having two replications because of the following reasons.

a. The selected palms were not having nuts of the same maturity for two replications.

b. Other palms of the selected varieties were not of the same age.

Thus only one nut each could be collected for twenty varieties/ cultivars. Two nuts were collected from the selected mother palm of the Komadan variety, popular in the southern districts of Kerala, from the isolated seed garden maintained at the Instructional farm, Vellayani.

The names of varieties/ cultivars selected for the study are listed below.

3.1.2. Varieties/cultivars with two replications.

Tall		Dwarf		Hybrid	
1.	Bombay	12.	Chowghat Orange Dwarf	18.	Fiji x Gangabondam
2.	Cochin China	13.	Chowghat Green Dwarf	19.	Gangabondam x Laccadive Ordinary
3.	Jamaica	14.	Gangabondam	20.	Keraganga
4.	Java	15.	Malayan Dwarf Yellow	21.	Kerasankara
5.	Kappadam	16.	Malayan Dwarf Orange	22.	Kerasowbhagya
6.	Navasi	17.	Thembli	23.	Chandrasankara
7.	Philippines			24.	Lakshaganga
8.	Sanramon				
9.	Siam				
10.	West Coast Tall				
11.	Komadan				

3.1.3 Varieties/cultivars without replication

Tall		Dwarf	
1.	Andaman Ordinary	12.	Andaman Dwarf
2.	Ayiramkachi	13.	Laccadive Ordinary
3.	Benza hybrid	14.	Laccadive Dwarf
4.	Ceylon	15.	Natural Cross Dwarf
5.	Fiji		Hybrids
6.	Godavari	16.	West Coast Tall x Laccadive Dwarf
7.	Gonthembli	17.	West Coast Tall x Chowghat Orange Dwarf
8.	Mysore	18.	Kerasree
9.	New Guinea	19.	Andaman Ordinary x Chowghat Orange Dwarf
10.	Spicata	20.	Cochin China x Chowghat Orange Dwarf
11.	Andaman Guinea		

3.2. Collection of samples from CRS, Balaramapuram

In order to study the effect of mineral nutrition on the quality and fatty acid composition of coconut oil, nuts were collected from the palms of an ongoing 3^3 confounded factorial experiment of CRS, Balaramapuram. This represented a 25 year old permanent fertilizer experiment with three levels of N (0, 340, 680 g/palm/year), P_2O_5 (0, 225, 450 g/palm/year) and K_2O (0, 450, 900 g/palm/year) respectively. The confounded treatments were NP^2K^2 in replication one and NPK^2 in replication two. Each plot has four palms per treatment per replication, each treatment replicated twice. The variety/cultivar used was West Coast Tall planted at a spacing of 7.5 x 7.5 m. Nitrogen, phosphorous and potassium were applied as Ammonium Sulphate, Super phosphate and Muriate of Potash respectively. There was no organic matter application in any of the treatments.

One nut each of uniform maturity was collected from two palms of the same age to represent a variety/cultivar.

3.2.1. The treatment combinations taken for the study are as follows.

1. $N_0P_0K_0$
2. $N_0P_0K_1$
3. $N_0P_0K_2$
4. $N_0P_1K_0$
5. $N_0P_1K_1$
6. $N_0P_1K_2$
8. $N_0P_2K_1$
9. $N_0P_2K_2$
10. $N_1P_0K_0$
11. $N_1P_0K_1$
12. $N_1P_0K_2$
13. $N_1P_1K_0$
14. $N_1P_1K_1$
15. $N_1P_1K_2$
16. $N_1P_2K_0$
17. $N_1P_2K_1$
18. $N_1P_2K_2$
19. $N_2P_0K_0$
20. $N_2P_0K_1$
21. $N_2P_0K_2$
22. $N_2P_1K_0$
23. $N_2P_1K_1$
24. $N_2P_1K_2$
25. $N_2P_2K_0$
26. $N_2P_2K_1$
27. $N_2P_2K_2$

3.3. Preparation of sample and laboratory analysis

The nuts collected were transported to the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, dehusked, split into halves and sun dried for a continuous period of six to seven days. The dried samples were then sliced into small pieces, packed in polythene bags and kept in a dessicator for analysis.

Samples were then subjected to chemical analysis and the methods used are furnished below.

3.3.1. Oil content

The sliced copra pieces were cut into small pieces again and a uniform sample of 0.5 g of copra was taken from each nut for the determination of oil content. The oil was extracted with petroleum ether in a percolation tube as per the cold percolation method of solvent extraction outlined by Kartha and Sethi, (1951).

3.3.2. Acid value

Acid value of the oil was estimated by dissolving a weighed quantity of oil in alcohol and titrating this against standard alkali using phenolphtalein as the indicator. Method as outlined by Paquot and Hautfenne, (1987) was followed.

3.3.3. Saponification value

Saponification value was estimated by refluxing a weighed quantity of oil with a known excess of alcoholic potash. After complete saponification the excess potash was determined by titration with standard hydrochloric acid. The method described by Paquot and Hautfenne, (1987) was followed.

3.3.4. Iodine value

The iodine value was determined by treating a known weight of the oil with a known excess of Wij's solution. The method outlined by Paquot and Hautfenne, (1987) was followed.

3.3.5. Reichert - Meissel value

Only selected varieties and treatments from a single replication were subjected to this analysis. The method outlined by Paquot and Hautfenne, (1987) was followed.

3.3.6. Polenske value

Only selected varieties and treatments from a single replication were subjected to this analysis. The method outlined by Paquot and Hautfenne, (1987) was followed.

3.3.7. Fractionation of fatty acids

The oil extracted from eleven selected varieties and five selected treatments of the fertilizer experiment was subjected to fractionation. Fatty acid composition of the oil was determined by analysis of the derived fatty acid methyl ester using packed column gas chromatography. Methyl esters of the fatty acids of coconut oil were prepared using a sealed vial method and transesterefication with sodium methoxide was done. The method outlined by Paquot and Hautfenne, (1987) was followed. The methyl esters were analysed in a Hewlett Packard Gas Chromatography using a 2m x 2m glass column packed with SP2330 packing (supelco) run for thirty minutes. An injection volume of 0.1 micro ml. of fatty acids were quantified from the chromatogram obtained and expressed as percentage.

3.3.8. Statistical analysis

The data from the different characters were subjected to statistical analysis according to the method outlined by Panse and Sukhatme, 1967. Analysis of variance was done for the twenty four varieties with two replications to study the effect of varietal variation on quality parameters. However, the twenty varieties with single replication were not tested statistically. The selected varieties and treatments subjected to Reichert-Meissel and Polenske value analysis also were not tested statistically.

RESULTS

4. RESULTS

In the present investigation an attempt was made to find out the effect of varietal variation and mineral nutrition on the oil content, quality parameters and fatty acid composition of coconut oil. The results of the study are furnished in the following pages with tables 1 to 9 and figures 1 to 24.

4.1. Varietal variation in relation to oil content and quality parameters

The results of the study was grouped into two. In the first category of 24 varieties with two replications, the results were subjected to statistical analysis and conclusions were drawn. The second category of 20 varieties were with no replication and hence were not subjected to statistical analysis. However, the analysis were made as precisely as possible and the results are presented.

4.1.1. Varieties with two replications

4.1.1.1. Oil content

Oil content of the varieties ranged from 60-78%. Komadan variety recorded the highest oil content of 78% followed by Cochin China and Sanramon (73%) (Fig.1).

Variety Malayan Dwarf Orange recorded the lowest oil content of 60%. The effect of varietal variation on the oil content was found to be significant (Table 1). Varieties Jamaica, West Coast Tall and the hybrid Fiji x Gangabondam had oil contents above 70%. Komadan was on a par with varieties Cochin China, Sanramon, Jamaica, West Coast Tall and Fiji x Gangabondam and significantly superior compared to other varieties in respect of oil content. Malayan Dwarf Orange was on par with varieties Kerasankara, Thembli, Chowghat Orange Dwarf, Malayan Dwarf Yellow, Siam, Chowghat Green Dwarf, Chandrasankara, Kerasowbhagya and Java.

4.1.1.2 Acid Value

The acid value of the varieties ranged from 0.71 - 5.44. Java recorded the highest value of 5.44 and Chowghat Green Dwarf the lowest acid value of 0.71. The effect of varietal variation on the acid value was found to be significant (Table 1). Java was on par with varieties Jamaica, Bombay and Sanramon and significantly superior compared to other varieties (Fig. 2).

4.1.1.3 Saponification value

Saponification value ranged from 221.83 - 264.53 among the varieties. Highest saponification value was recorded in variety Keraganga (264.53) followed by West Coast Tall (263.19). Lowest saponification value was recorded in Malayan Dwarf Orange. The effect of varietal variation on the saponification value was found to be significant (Table 1). Varieties Malayan Dwarf Yellow, Malayan Dwarf Orange and Thembli had low saponification values in the range of 221.83 - 227.33. Varieties Cochin China, Kappadam, Navasi, Philippines, Siam, West Coast Tall, Keraganga and Lakshaganga had saponification values greater than 260 (Fig. 3). Keraganga was found to be on a par with varieties Sanramon, Kerasowbhagya, Jamaica, Fiji x Gangabondam, Gangabondam, Java, Gangabondam x Laccadive Ordinary, Chandrasankara, Kerasankara, Chowghat Orange Dwarf, Philippines, Cochin China, Navasi, Bombay, Lakshaganga, Siam, Kappadam and significantly superior compared to other varieties. Malayan Dwarf Orange was found to be on a par with varieties Malayan Dwarf Yellow and Thembli and significantly inferior compared to other varieties with respect to saponification value.

4.1.1.4 Iodine value

Iodine value of the varieties ranged from 4.09 - 11.66. Highest iodine value was recorded in the variety Jamaica (11.66) followed by Java (10.46), Siam (10.20) and Lakshaganga (10.17). The lowest iodine value was recorded

Table 1. Oil content and Quality parameters of varieties from germplasam collection, Pilicode.

Sl. No.	Variety/Cultivar	Oil Content %	Quality Parameters		
			Acid Value	Saponification value	Iodine value
1.	Bombay	68.50	4.47	261.83	9.07
2.	Cochin China	73.00	1.68	260.48	9.30
3.	Jamaica	72.50	5.32	252.78	11.66
4.	Java	67.00	5.44	256.24	10.46
5.	Kappadam	69.50	1.01	263.02	8.78
6.	Navasi	68.00	2.25	260.71	9.07
7.	Philippines	69.00	1.54	260.39	7.37
8.	Sanramon	73.00	3.35	251.42	8.38
9.	Siam	66.00	1.12	261.89	10.20
10.	West Coast Tall	72.00	1.96	263.19	7.58
11.	Komadan	78.00	0.82	241.19	4.62
12.	Chowghat Orange Dwarf	65.00	0.96	259.71	8.57
13.	Chowghat Green Dwarf	67.00	0.71	245.74	4.09
14.	Gangabondam	68.00	1.12	256.20	9.21
15.	Malayan Dwarf Yellow	66.00	1.29	227.16	4.69
16.	Malayan Dwarf Orange	60.00	1.81	221.83	4.41
17.	Thembli	64.00	1.33	227.33	5.15
18.	Fiji x Gangabondam	71.00	1.12	254.54	7.79
19.	Keraganga	68.00	2.11	264.53	9.28
20.	Kerasankara	63.00	0.98	259.30	8.06
21.	Kerasowbhagya	67.00	0.97	251.90	9.23
22.	Chandrasankara	67.00	1.93	257.79	8.68
23.	Lakshaganga	61.00	1.26	261.88	10.17
24.	Gangabondam x Laccadive Ordinary	68.00	1.78	257.37	7.56
	C.D.	7.13	2.40	15.62	3.22

in Chowghat Green Dwarf (4.09). The effect of varietal variation on the iodine value was found to be significant (Table 1). Iodine value of Jamaica was found to be on a par with varieties Java, Siam, Lakshaganga, Cochin China, Keraganga, Kerasowbhagya, Gangabondam, Navasi, Bombay, Kappadam, Chandrasankara and Chowghat Orange Dwarf and significantly superior compared to other varieties. Chowghat Green Dwarf was found to be on a par with varieties Malayan Dwarf Orange, Komadan, Malayan Dwarf Yellow and Thembli and significantly inferior compared to other varieties (Fig. 4).

4.1.2. Varieties without replication

4.1.2.1. Oil Content

Oil content of this group of varieties ranged between 50-76% (Table 2). Varieties Gonthembli, Laccadive Ordinary and Laccadive Dwarf recorded a high value of 76%. Andaman Dwarf recorded the lowest oil percentage of 50 (Fig. 1).

Among the tall varieties Andaman ordinary, Ayiramkachi and Benza hybrid gave an oil content of 70% and Spicata another tall variety recorded an oil content of 72%. New Guinea a tall variety recorded the lowest value of 56%. Natural Cross Dwarf had an oil content of 66%. Oil content of the hybrids ranged from 60-68%. Among the hybrids Cochin China x Chowghat Orange Dwarf recorded the highest oil content of 68% and Andaman Ordinary x Chowghat Orange Dwarf registered the lowest value of 60%.

4.1.2.2. Acid value

Acid value of the 20 varieties ranged between 0.53 to 7.56. Andaman Ordinary x Chowghat Orange Dwarf recorded the highest acid value and Natural Cross Dwarf recorded the lowest acid value (Table 2).

Among the tall varieties Fiji and Godavari had an acid value less than 1. Gonthembli and Ayiramkachi had an acid value more than 2.5. Andaman Ordinary had the highest acid value of 3.66 among this category.

Among the dwarf varieties, Natural Cross Dwarf reported the lowest acid value of 0.53 followed by Laccadive Dwarf with 0.54. Andaman Dwarf had the highest value of 2.8 among the dwarf varieties.

Among the hybrids, Andaman Ordinary x Chowghat Orange Dwarf recorded the highest acid value of 7.56 followed by Cochin China x Chowghat Orange Dwarf (3.36). The other hybrids had an average acid value of 0.80 (Fig. 2).

Table 2. Oil Content and Quality parameters of varieties (without replication) from germplasm collection, Pilicode.

Sl. No.	Variety/Cultivar	Oil Content %	Quality Parameters		
			Acid Value	Saponi-fication Value	Iodine Value
1.	Andaman Ordinary	70.00	3.66	252.00	12.70
2.	Ayiramkachi	70.00	2.81	263.03	6.02
3.	Benza hybrid	70.00	1.69	241.18	4.44
4.	Ceylon	64.00	1.39	263.36	9.36
5.	Fiji	68.00	0.83	254.80	10.69
6.	Godavari	68.00	0.56	257.82	9.36
7.	Gonthembli	76.00	2.51	243.60	9.52
8.	Mysore	66.00	4.48	260.59	8.83
9.	New Guinea	56.00	3.06	260.59	7.30
10.	Spicata	72.00	1.39	268.80	12.09
11.	Andaman Guinea	64.00	1.69	249.50	13.33
12.	Andaman Dwarf	50.00	2.80	255.05	10.88
13.	Laccadive Ordinary	76.00	1.39	263.36	7.41
14.	Laccadive Dwarf	76.00	0.54	260.51	6.58
15.	Natural Cross Dwarf	66.00	0.53	266.13	9.68
16.	West Coast Tall x Laccadive Dwarf	66.00	0.83	240.80	9.07
17.	West Coast Tall x Chowghat Green Dwarf	64.00	0.84	260.51	7.31
18.	Cochin China x Chowghat Orange Dwarf	68.00	3.36	268.80	9.24
19.	Andaman Ordinary x Chowghat Orange Dwarf	60.00	7.56	243.96	12.70
20.	Kerasree	62.00	0.83	266.13	11.11
	Mean	66.60	2.14	257.03	9.41

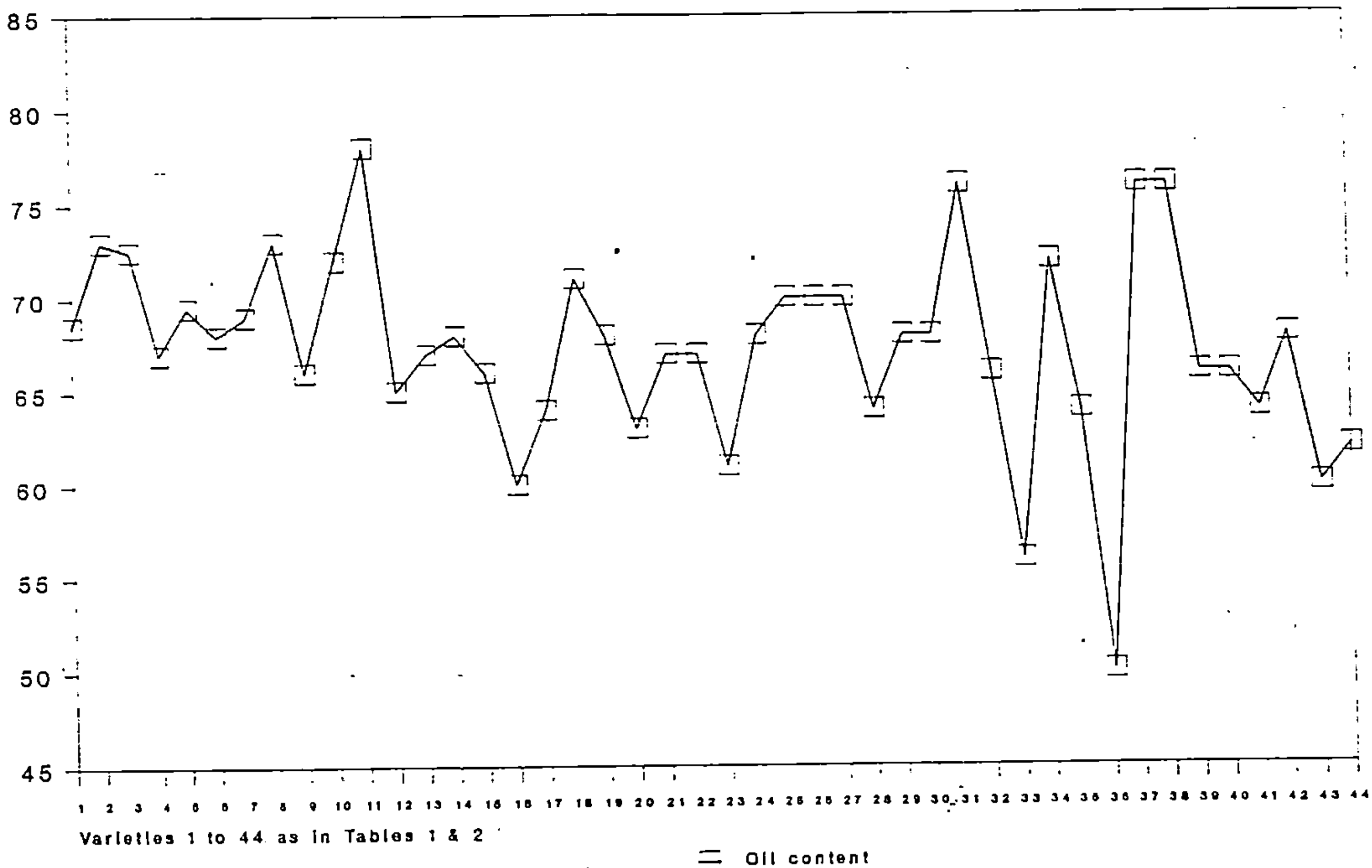


Fig. 1. Oil content of coconut varieties collected from RARS, Pilicode (Mean values)

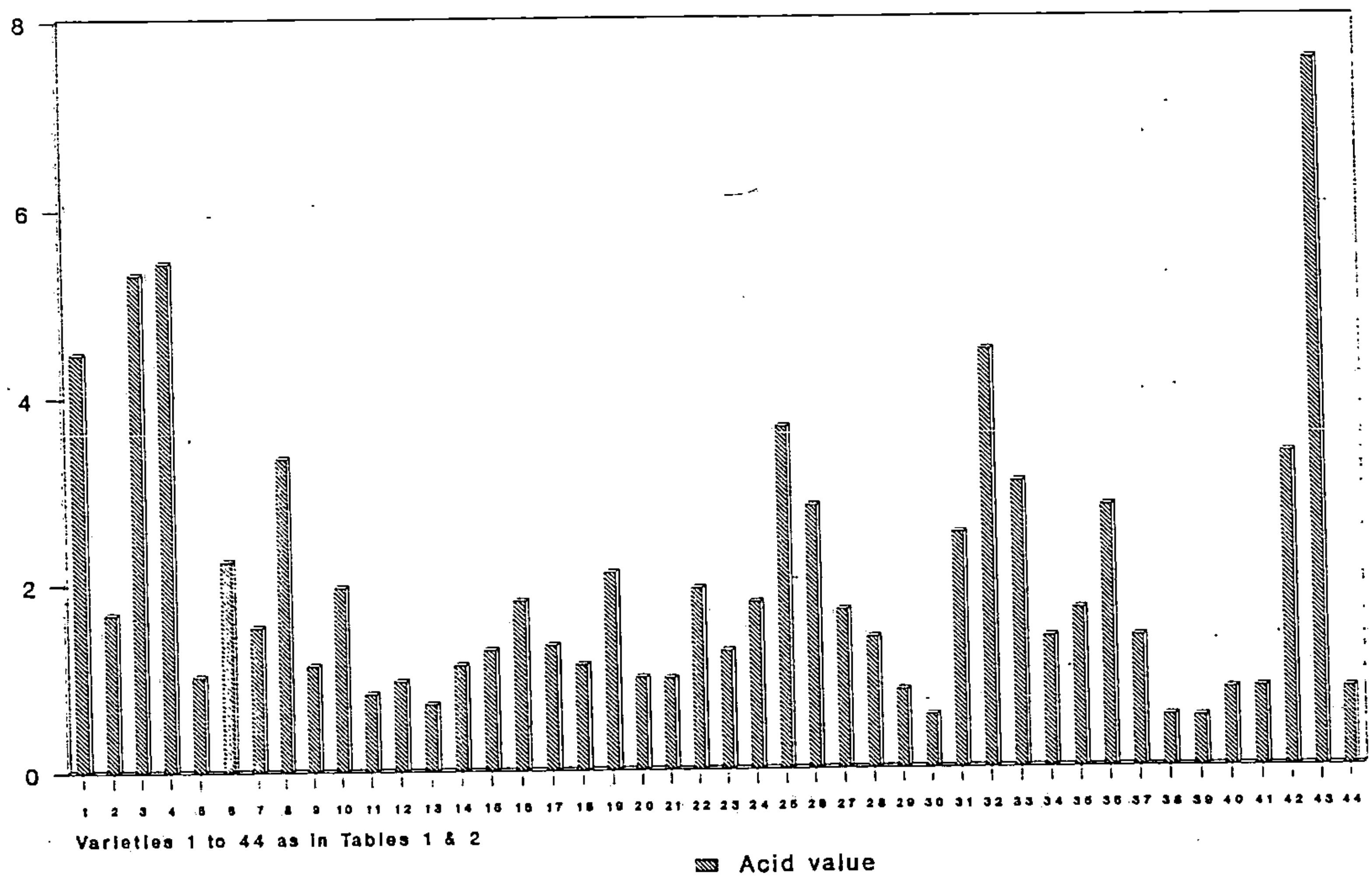


Fig. 2. Acid value of coconut varieties collected from RARS, Pilicode (Mean values)

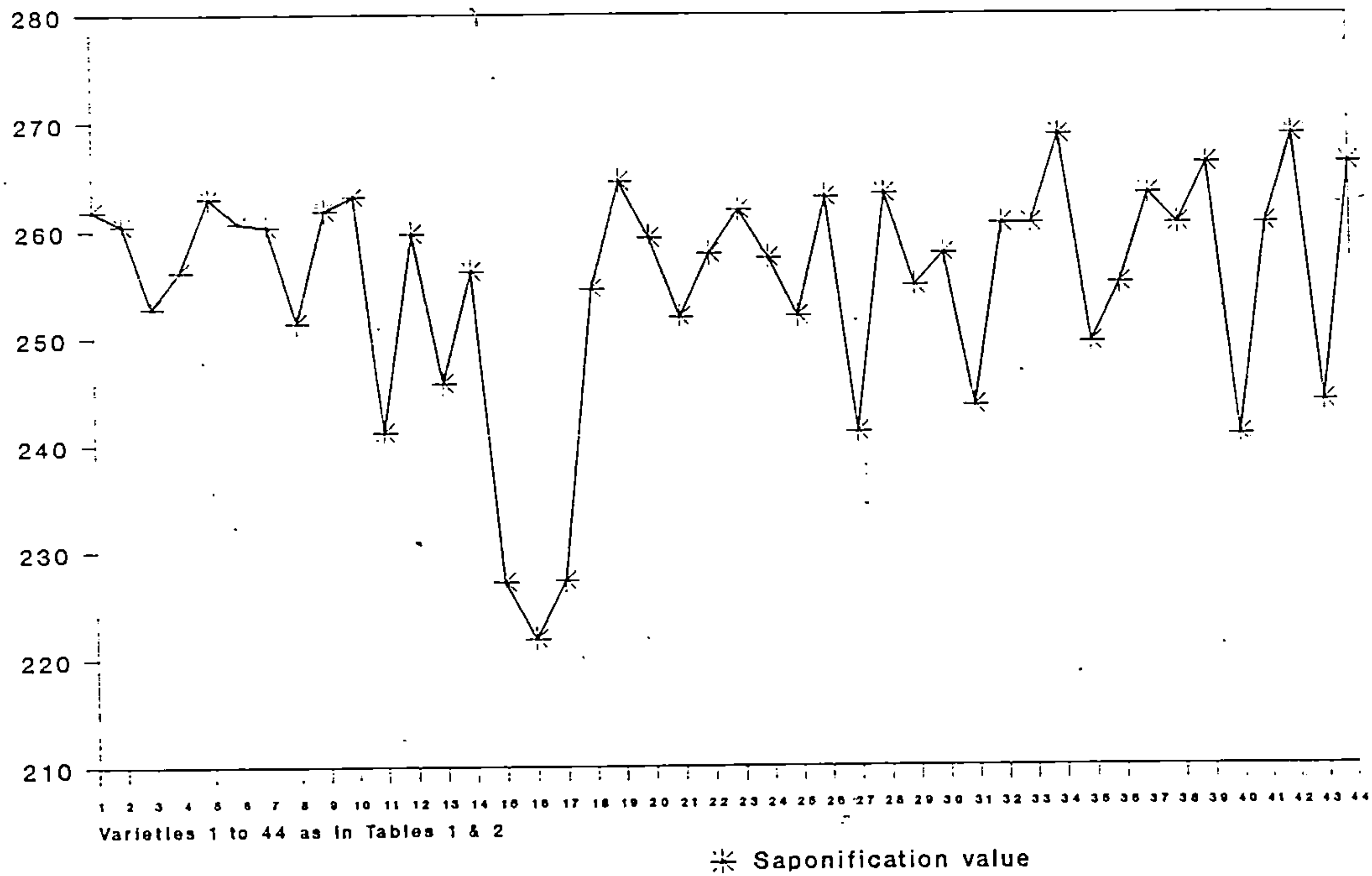


Fig. 3. Saponification value of coconut varieties collected from RARS, Pilicode (Mean values)

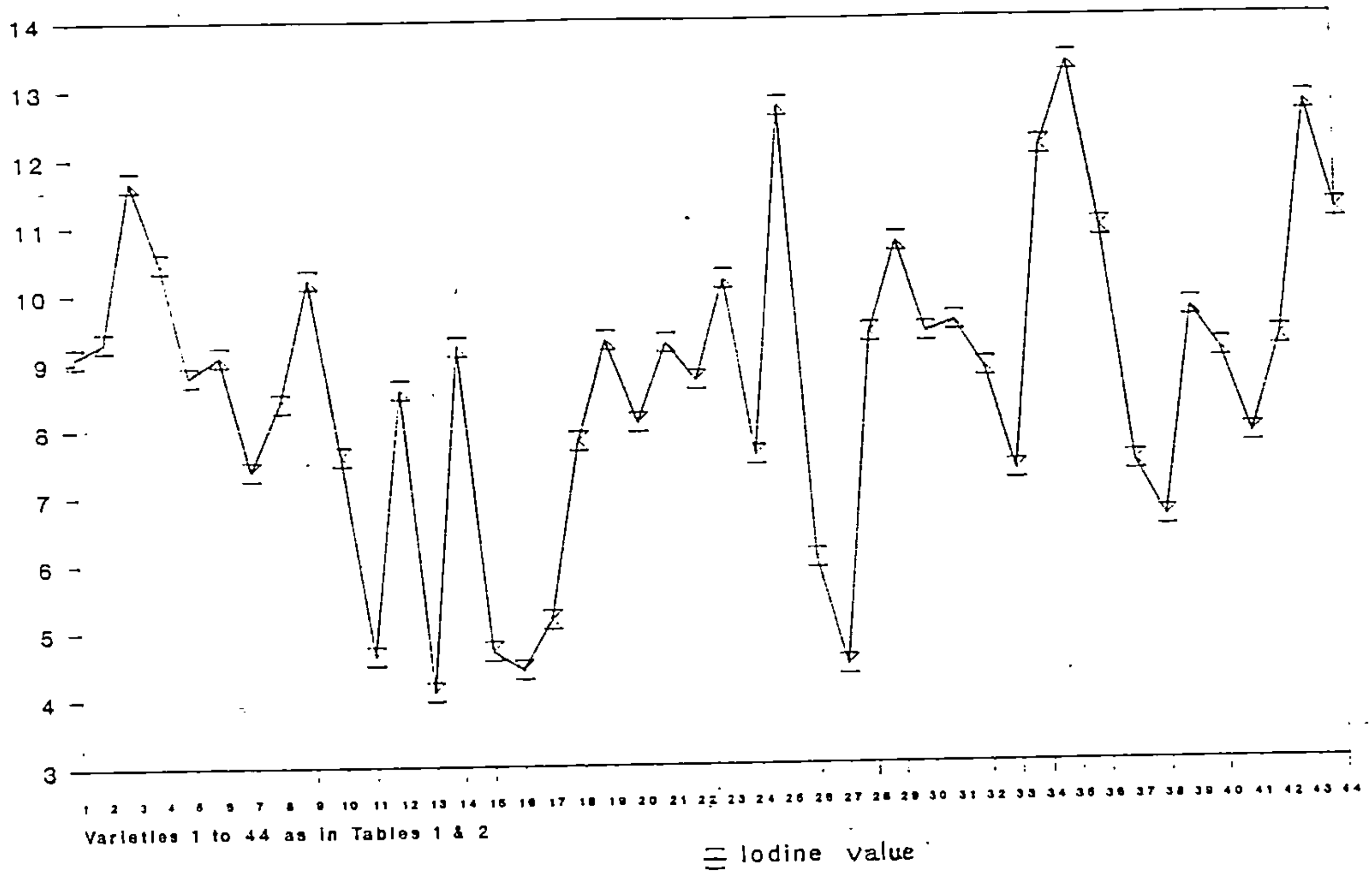


Fig. 4. Iodine value of coconut varieties collected from RARS, Pilicode (Mean values)

4.1.2.3. Saponification value

Saponification value of the varieties ranged between 240.80 - 268.80 (Table 2). Spicata recorded the highest saponification value and West Coast Tall x Laccadive Dwarf gave the lowest value.

Among the tall varieties Spicata gave the highest saponification value of 268.80. Tall varieties Mysore, New Guinea, Ceylon and Ayiramkachi had saponification value greater than 260. Andaman Guinea, another tall variety gave a low saponification value of 249.50. Dwarf variety Natural Cross Dwarf gave the highest value of 266.13 followed by Laccadive Ordinary (263.36). Hybrid, Cochin China x Chowghat Orange Dwarf recorded a saponification value of 268.80 followed by Kerasree (266.13). West Coast Tall x Laccadive Dwarf gave a low value of 240.80 followed by Andaman Ordinary x Chowghat Orange Dwarf (243.96) (Fig. 3).

4.1.2.4. Iodine Value

Iodine value ranged between 4.44 to 13.33 among the 20 varieties (Table 2). Andaman Guinea recorded the highest iodine value and Benza Hybrid gave the lowest iodine value (Fig. 4).

Among the tall varieties, Andaman Guinea gave the highest iodine value (13.33) followed by Andaman Ordinary (12.70). Godavari, Gonthembli and Ceylon recorded values greater than 9. Spicata, another tall variety showed a high value of 12.09.

Dwarf variety, Andaman Dwarf recorded a high iodine value of 10.88 followed by Natural Cross Dwarf (9.68). Laccadive Dwarf recorded a low iodine value of 6.58.

Among the hybrids Andaman Ordinary x Chowghat Orange Dwarf gave the highest value of 12.70 followed by Kerasree (11.11). West Coast Tall x Chowghat Green Dwarf gave a comparatively low iodine value of 7.81.

4.1.2.5. Reichert - Meissel (R.M.) value and Polenske value (P.V.)

These two quality constants which are of lesser importance in quality assessment of oils, were done in 28 selected varieties and the results are presented below.

The R.M. value of the varieties ranged between 7.70 - 10.67 (Table 3). Kerasankara, a hybrid recorded the highest value of 10.67 and Spicata, a tall variety recorded

Table 3. Reichert-Meissel and Polenske values of selected varieties.

Sl. No.	Variety	R.M. Value	P. Value
1.	Benza hybrid	9.24	14.64
2.	Ceylon	9.90	16.72
3.	Ayiramkachi	9.35	17.82
4.	Siam	10.01	18.15
5.	Spicata	7.70	14.85
6.	Fiji	8.50	18.50
7.	West Coast Tall	9.90	16.72
8.	Sanramon	9.02	16.94
9.	Philippines	9.24	16.28
10.	Jamaica	10.23	17.82
11.	Kappadam	9.79	17.27
12.	Komadan	8.25	14.63
13.	Malayan Yellow Dwarf	8.47	16.17
14.	Malayan Green Dwarf	8.88	17.16
15.	Malayan Orange Dwarf	8.88	14.96
16.	Chowghat Orange Dwarf	8.25	16.72
17.	Laccadive Ordinary	8.69	14.85
18.	Gangabondam	9.13	15.40
19.	Kerasankara	10.67	15.18
20.	Keraganga	9.35	17.05
21.	Chandra Sankara	8.91	15.73
22.	Kerasowbhagya	8.91	15.73
23.	Kerasree	8.69	15.40
24.	Lakshaganga	8.25	16.89
25.	Gangabondam x Laccadive Ordinary	9.46	16.06
26.	West Coast Tall x Laccadive Dwarf	8.91	15.51
27.	Fiji x Gangabondam	9.68	16.50
28.	Cochin China x Chowghat Orange Dwarf	9.24	14.63
	Mean	9.12	16.22

the lowest value of 7.70. On an average, the tall varieties had a slightly higher R.M. value compared to the hybrids. Dwarfs had a lower value compared to the tall and hybrids. Among the tall varieties, Jamaica had a high value (10.23) followed by West Coast Tall and Ceylon (9.90). Among the dwarf varieties, Gangabondam had the highest value of 9.13 followed by Malayan Green Dwarf and Malayan Orange Dwarf (8.80). Among the hybrids, Kerasankara recorded the highest value of 10.67 and Kerasree the lowest (8.69). Keraganga, Gangabondam x Laccadive Ordinary, Fiji x Gangabondam and Cochin China x Chowghat Orange Dwarf gave R.M. values above 9.

The Polenske value of the varieties ranged from 14.63 - 18.50 (Table 3). Fiji, a tall variety recorded the highest value of 18.50. Tall varieties Benza hybrid, Komadan and the hybrid Cochin China x Chowghat Orange Dwarf recorded the lowest value (14.63). On an average, the P.V. recorded were 16.69, 15.87 and 15.86 for tall, dwarf and hybrids respectively.

4.1.3. Fractionation of fatty acids

The oil from the selected varieties which were subjected to gas liquid chromatography showed considerable variation in the fatty acid composition (Fig.9-19). The distribution pattern of fatty acids from the different varieties showed that saturated fatty acids amounted to 94.69% while unsaturated fatty acids was only 5.30%. They mostly comprised short and medium chain saturated fatty acids like Caproic (C6:0), Caprylic (C8:0), Capric (C10:0), Lauric (C12:0) and Myristic acids (C14:0). Linoleic acid was found in small amounts and linolenic acid was seen in traces. Among the saturated fatty acids, lauric acid was the dominant (43.26%) followed by myristic acid (18.83%) (Table 4).

Caproic acid for the different varieties ranged from 0.87 - 2.37%. Variety Gangabondam x Laccadive Dwarf recorded the lowest content of 0.87 and Jamaica the highest content of 2.37%. Most of the varieties had a caproic acid content above 1%.

Caprylic acid content ranged between 10.71 to 19.64% among the varieties. Hybrid Keraganga recorded the highest content (19.64%) followed by West Coast Tall (15.41%). Varieties Sanramon, Laccadive Ordinary, Malayan Yellow Dwarf, Gangabondam x Laccadive Dwarf and Kerasankara had caprylic acid contents above 13%.

Capric acid content ranged from 6.82 - 10.26%. The highest value was reported in Keraganga (10.26%) followed by West Coast Tall (9.79%). The lowest content was recorded in Gangabondam x Laccadive Dwarf. In most of the varieties the content was above 8%.

Table 4. Fatty acid Composition of Selected varieties

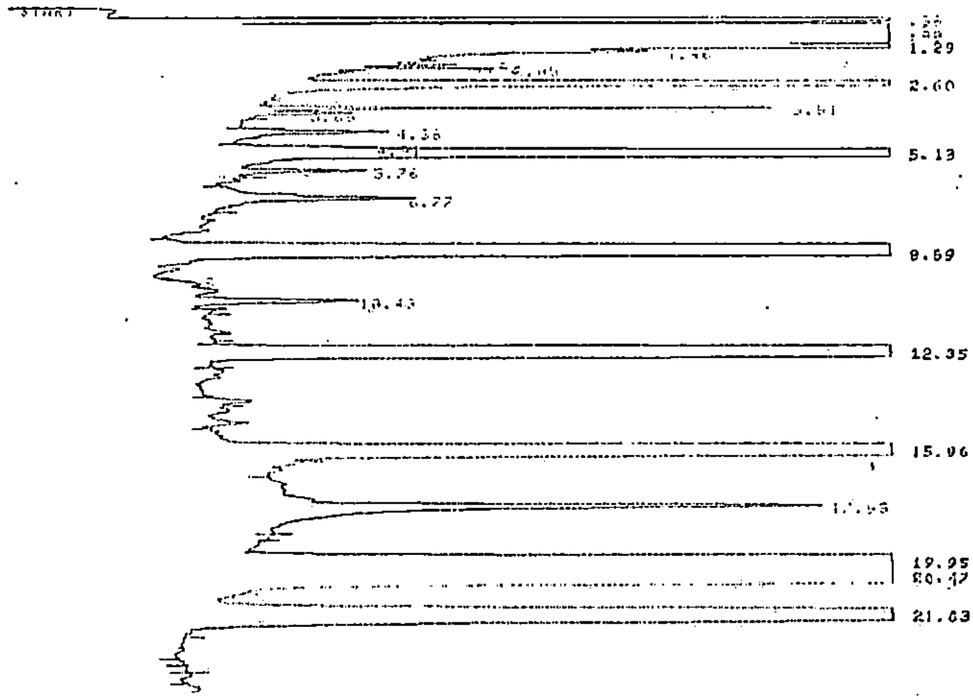
Sl. No.	Variety	Caproic acid $C_{6}:0$	Caprylic acid $C_{8}:0$	Capric acid $C_{10}:0$	Lauric acid $C_{12}:0$	Myristic acid $C_{14}:0$	Palmitic acid $C_{16}:0$	Stearic acid $C_{18}:0$	Linoleic acid $C_{18}:1$	Linolenic acid $C_{18}:2$
1.	Sanramon	1.90	13.10	8.87	37.77	20.72	8.39	2.27	5.75	1.21
2.	Kappadam	1.19	11.15	8.22	38.41	21.52	9.29	2.75	6.32	1.14
3.	Philippines	1.01	12.13	7.50	49.28	17.36	6.90	1.49	3.83	0.49
4.	West Coast Tall	2.13	15.41	9.79	40.71	19.03	6.65	1.75	3.71	0.82
5.	Jamaica	2.37	10.71	9.41	30.86	23.76	11.90	2.68	6.74	1.57
6.	Laccadive Ordinary	1.24	13.85	8.01	47.04	17.67	6.09	1.49	4.00	0.60
7.	Malayan Yellow Dwarf	1.28	13.36	9.00	50.51	16.15	5.41	0.90	2.82	0.56
8.	Lakshaganga	1.51	11.67	9.09	34.84	23.97	9.00	2.53	6.00	1.38
9.	Keraganga	1.46	19.64	10.26	49.93	11.65	3.98	0.77	1.85	0.45
10.	Kerasankara	1.25	14.03	7.22	50.62	16.14	5.28	1.37	3.30	0.77
11.	Gangabondam x Laccadive Ordinary	2.87	13.44	6.82	45.85	19.12	7.36	1.49	4.04	1.00
	Mean	1.47	13.50	8.56	43.26	18.83	7.30	1.77	4.40	0.91

Lauric acid was the dominant acid in all the varieties and ranged from 30.86 - 50.62%. Kerasankara recorded the highest value of 50.62% followed by Malayan Yellow Dwarf (50.51%). Philippines and Keraganga had contents above 49%. Varieties Lakshaganga, Sanramon and Kappadam had contents of 34.84%, 37.77% and 38.41% respectively.

Myristic acid content ranged from 11.65% - 23.97% with a mean value of 18.83%. Highest content was reported in Lakshaganga followed by Jamaica (23.76%). Varieties Sanramon and Kappadam had contents above 20%. The lowest content was recorded in variety Keraganga (11.65%) followed by Malayan Yellow Dwarf (16.15%) and Kerasankara (16.14%).

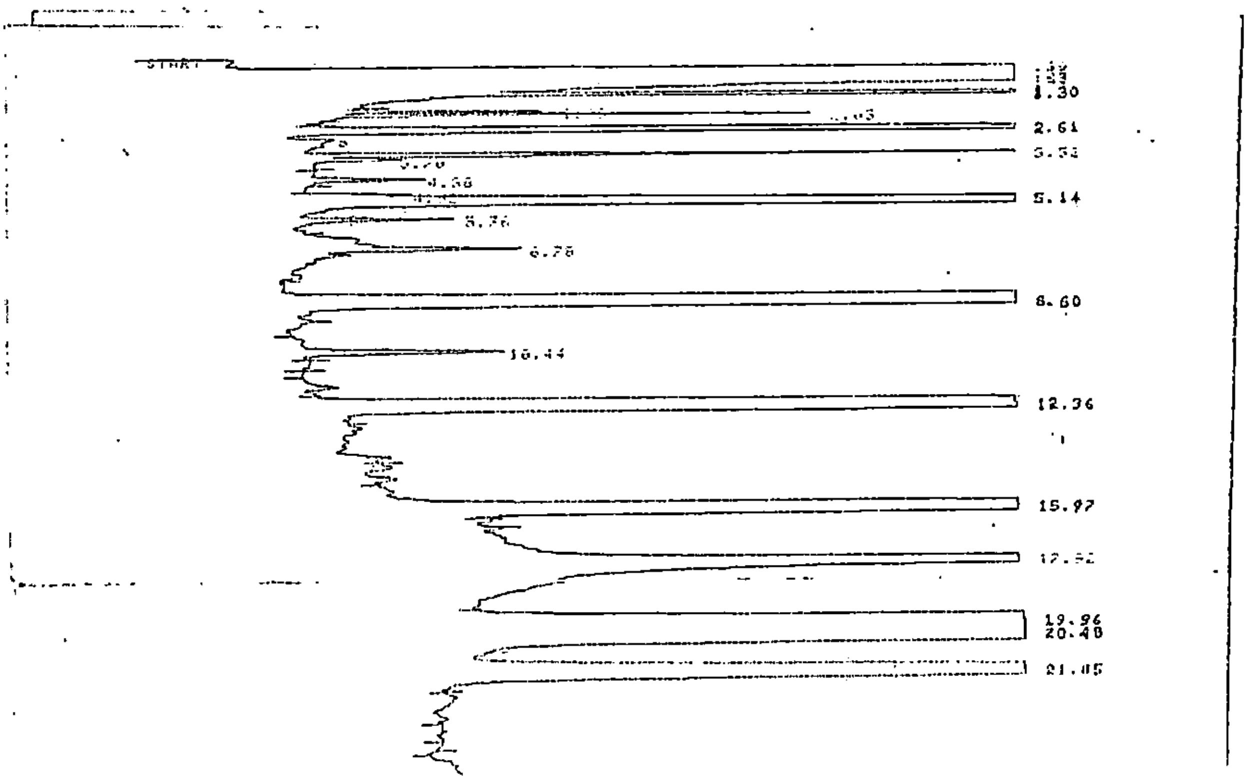
Palmitic acid content ranged from 3.98 - 11.90% with a mean value of 7.30%. The highest content was recorded in Jamaica (11.90%) followed by Kappadam (9.29%) and Lakshaganga (9%). Lowest content was recorded in Keraganga (3.98%) followed by Kerasankara (5.28%) and Malayan Yellow Dwarf (5.40%). Varieties Philippines, Laccadive Ordinary and West Coast Tall had values above 6%.

Stearic acid content ranged from 0.77 - 2.75%. Kappadam recorded the highest content of 2.75 and Keraganga the lowest content of 0.77%. Varieties Lakshaganga, Fig: 9 Chromatogram of variety Sanramon



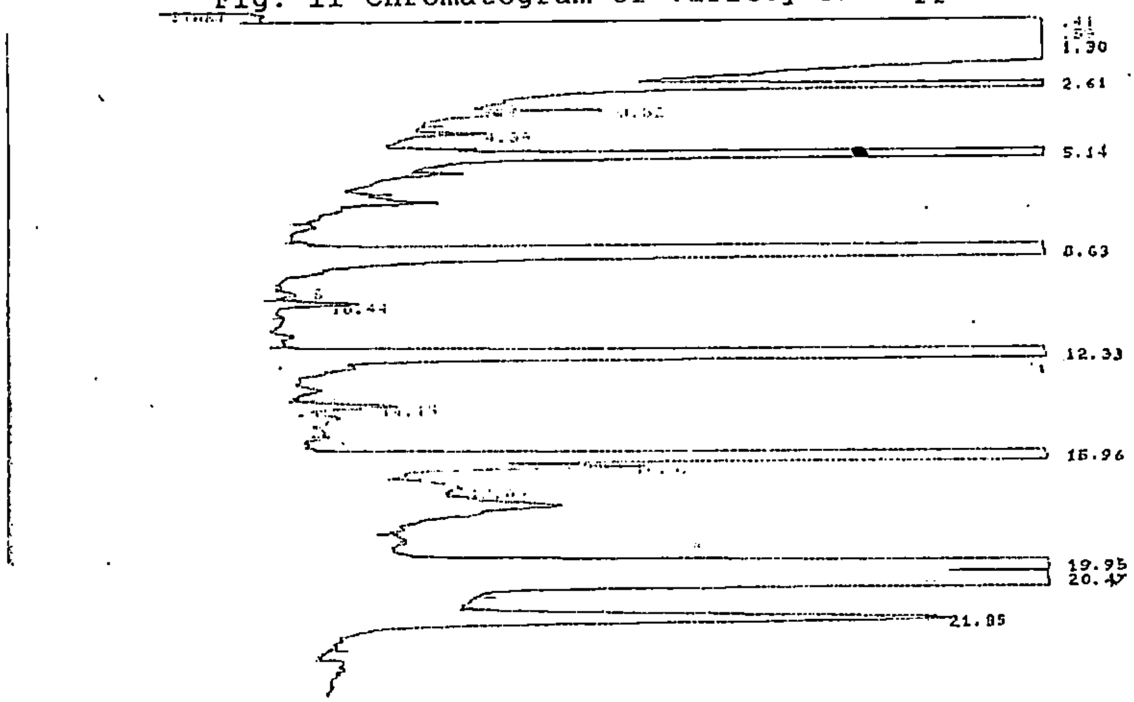
Fatty acid	RT	Area %	Content %
Caproic acid	1.29	1.304	1.90
Caprylic acid	2.60	8.970	13.10
Capric acid	5.13	6.075	8.87
Lauric acid	8.59	25.862	37.77
Myristic acid	12.35	14.191	20.72
Palmitic acid	15.96	5.744	8.39
Stearic acid	19.95	1.555	2.27
Linoleic acid	20.47	3.940	5.75
Linolenic acid	21.83	0.830	1.21

Fig. 10 Chromatogram of variety Kappadam



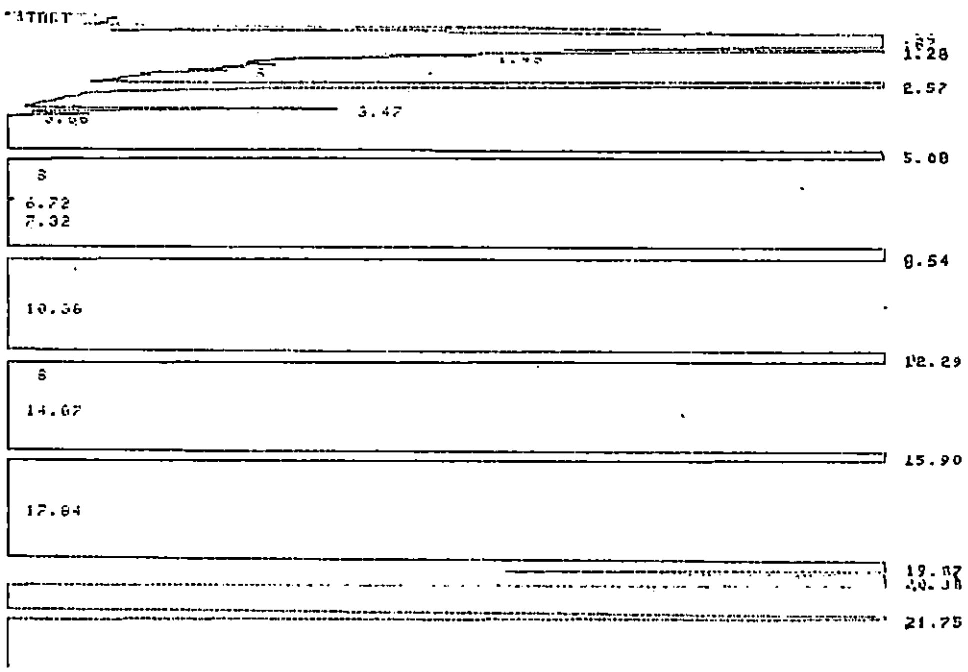
Fatty acid	RT	Area %	Content %
Caproic acid	1.30	0.834	1.19
Caprylic acid	2.61	7.788	11.15
Capric acid	5.14	5.737	8.22
Lauric acid	8.60	26.819	38.41
Myristic acid	12.36	15.026	21.52
Palmitic acid	15.97	6.484	9.29
Stearic acid	19.96	1.918	2.75
Linoleic acid	20.48	4.415	6.32
Linolenic acid	21.85	0.799	1.14

Fig. 11 Chromatogram of variety Philippines



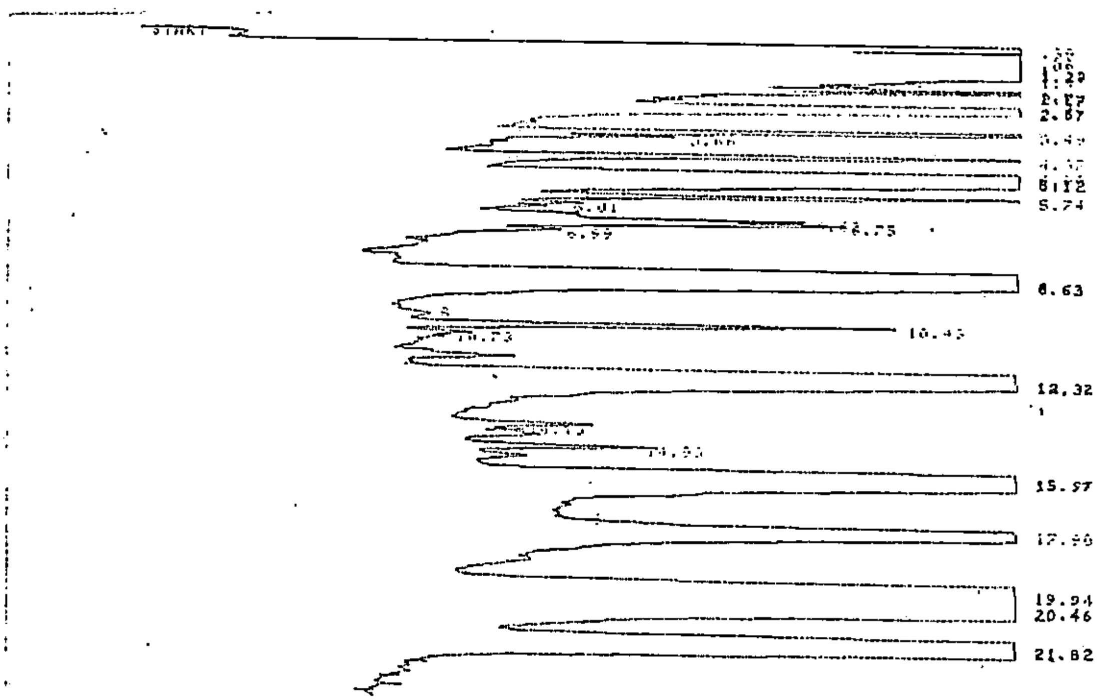
Fatty acid	RT	Area %	Content %
Caproic acid	1.30	0.423	1.01
Caprylic acid	2.61	5.074	12.13
Capric acid	5.14	3.137	7.50
Lauric acid	8.63	20.609	49.28
Myristic acid	12.33	7.261	17.36
Palmitic acid	15.96	2.888	6.90
Stearic acid	19.95	0.623	1.49
Linoleic acid	20.47	1.603	3.83
Linolenic acid	21.85	0.204	0.49

Fig. 12 Chromatogram of variety West Coast Tall



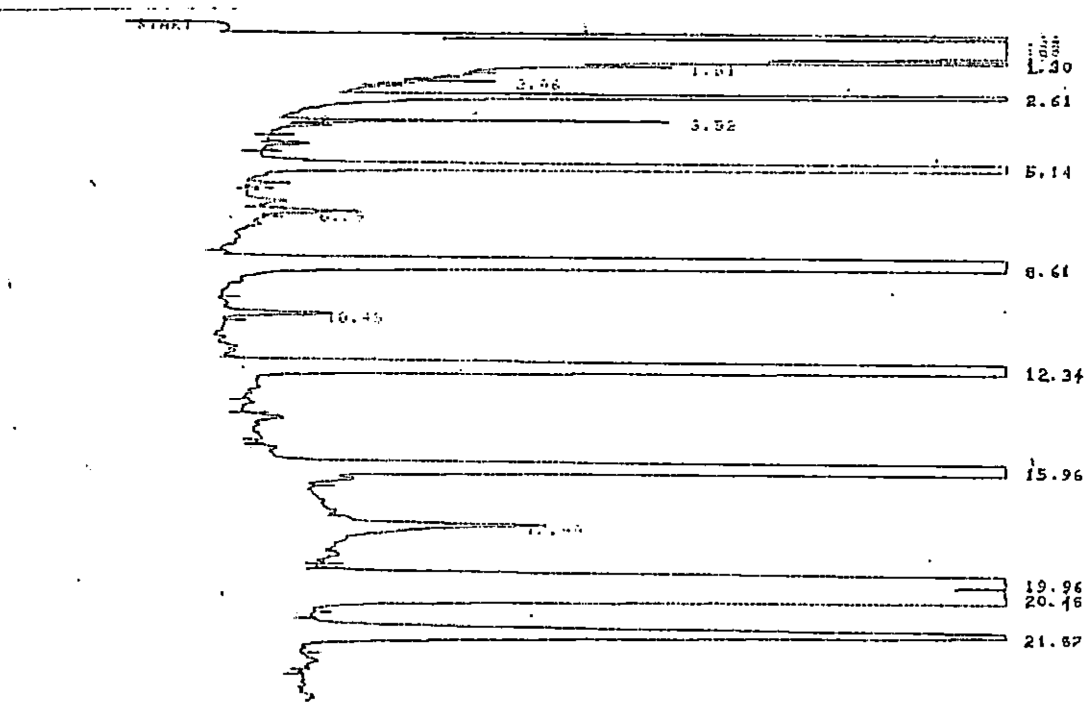
Fatty acid	RT	Area %	Content %
Caproic acid	1.28	1.480	2.13
Caprylic acid	2.57	10.716	15.41
Capric acid	5.08	6.810	9.79
Lauric acid	8.54	28.316	40.71
Myristic acid	12.29	13.237	19.03
Palmitic acid	15.90	4.626	6.65
Stearic acid	19.87	1.218	1.75
Linoleic acid	20.38	2.580	3.71
Linolenic acid	21.75	0.569	0.82

Fig. 13 Chromatogram of variety Jamaica



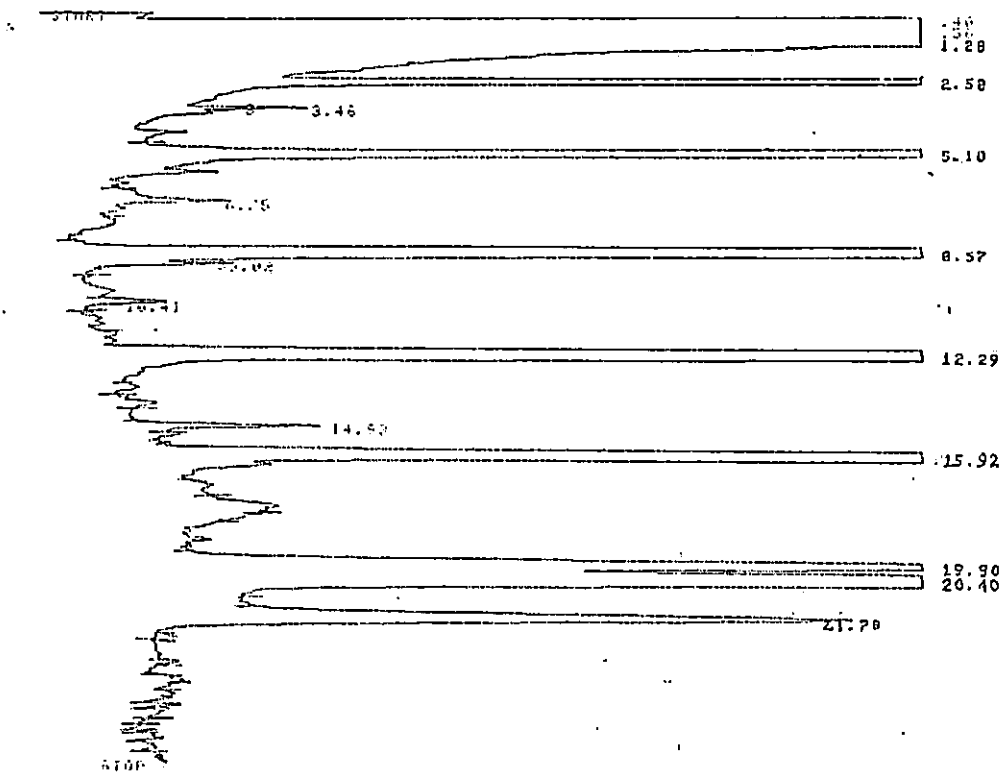
Fatty acid	RT	Area %	Content %
Caproic acid	1.28	1.775	2.37
Caprylic acid	2.57	8.008	10.71
Capric acid	5.12	7.039	9.41
Lauric acid	8.63	23.081	30.86
Myristic acid	12.32	17.772	23.76
Palmitic acid	15.97	8.905	11.90
Stearic acid	19.94	2.006	2.68
Linoleic acid	20.46	5.039	6.74
Linolenic acid	21.82	1.172	1.57

Fig. 14 Chromatogram of variety Laccadive Ordinary



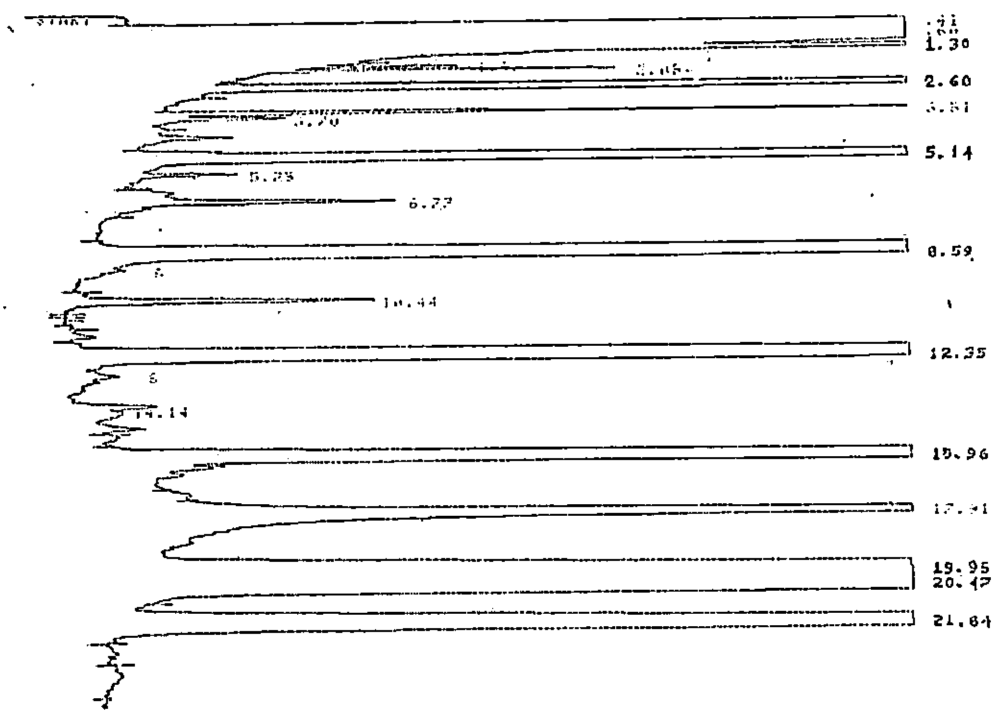
Fatty acid	RT	Area %	Content %
Caproic acid	1.30	0.738	1.24
Caprylic acid	2.61	8.207	13.85
Capric acid	5.14	4.745	8.01
Lauric acid	8.61	27.873	47.04
Myristic acid	12.34	10.468	17.67
Palmitic acid	15.96	3.612	6.09
Stearic acid	19.96	0.883	1.49
Linoleic acid	20.48	2.370	4.00
Linolenic acid	21.87	0.358	0.60

Fig. 15 Chromatogram of variety Malayan Yellow Dwarf



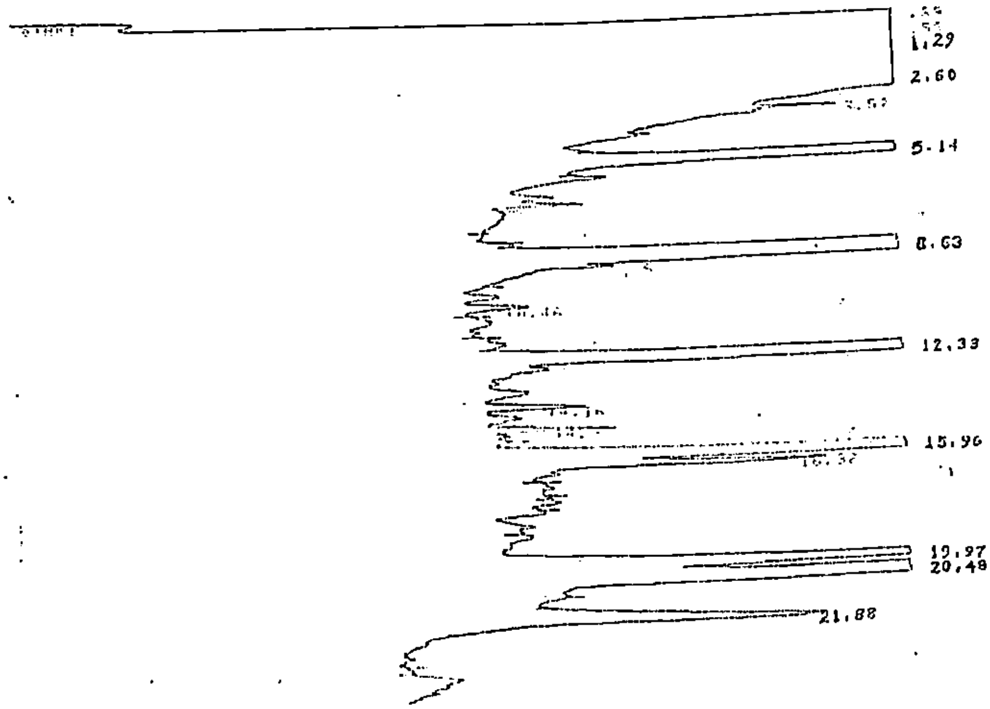
Fatty acid	RT	Area %	Content %
Caproic acid	1.28	0.690	1.28
Caprylic acid	2.58	7.186	13.36
Capric acid	5.10	4.843	9.00
Lauric acid	8.57	27.168	50.51
Myristic acid	12.29	8.687	16.15
Palmitic acid	15.92	2.909	5.41
Stearic acid	19.90	0.482	0.90
Linoleic acid	20.40	1.516	2.82
Linolenic acid	21.78	0.301	0.56

Fig. 16 Chromatogram of variety Lakshaganga



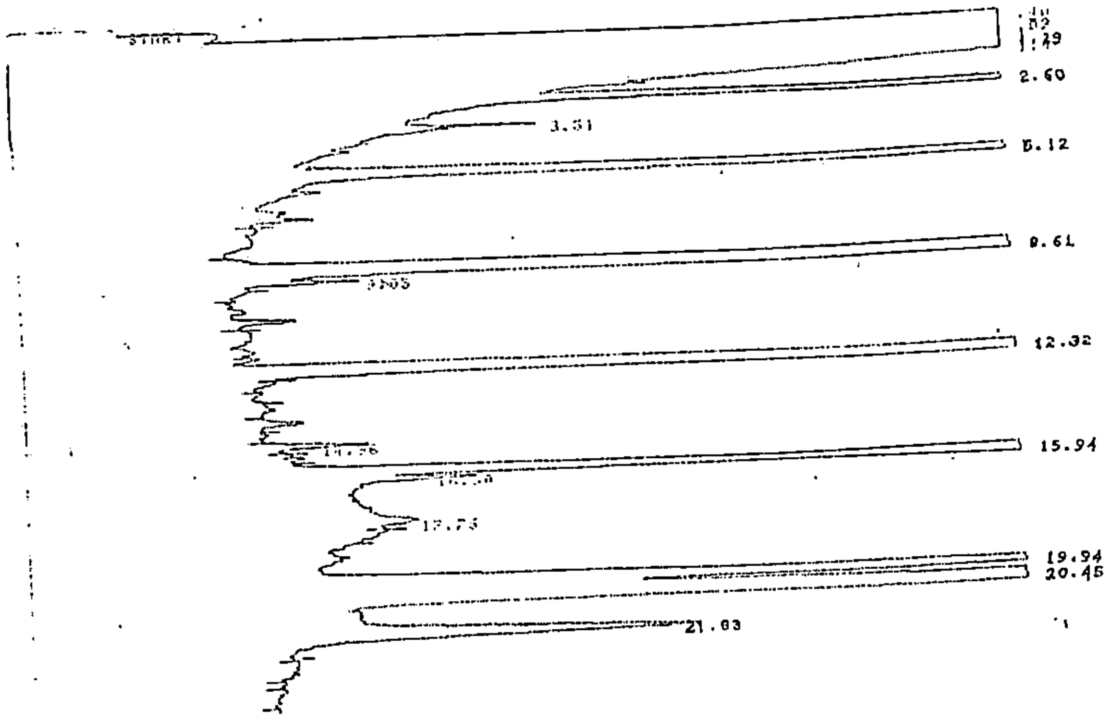
Fatty acid	RT	Area %	Content %
Caproic acid	1.30	1.109	1.51
Caprylic acid	2.60	8.541	11.67
Capric acid	5.14	6.652	9.09
Lauric acid	8.59	25.498	34.84
Myristic acid	12.35	17.551	23.97
Palmitic acid	15.96	6.591	9.00
Stearic acid	19.95	1.849	2.53
Linoleic acid	20.47	4.388	6.00
Linolenic acid	21.84	1.014	1.38

Fig. 17 Chromatogram of variety Keraganga



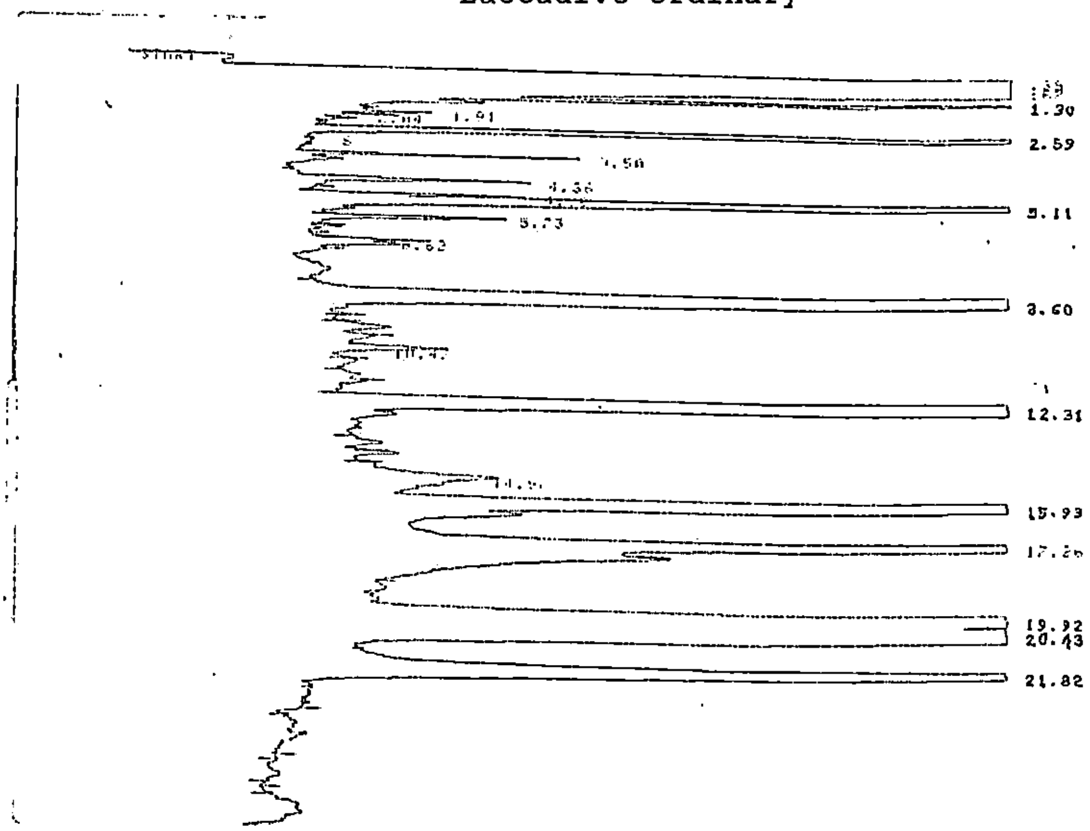
Fatty acid	RT	Area %	Content %
Caproic acid	1.29	0.444	1.46
Caprylic acid	2.60	5.982	19.64
Capric acid	5.14	3.125	10.26
Lauric acid	8.63	15.205	49.93
Myristic acid	12.33	3.547	11.65
Palmitic acid	15.96	1.212	3.98
Stearic acid	19.97	0.235	0.77
Linoleic acid	20.48	0.564	1.85
Linolenic acid	21.88	0.137	0.45

Fig. 18 Chromatogram of variety Kerasankara



Fatty acid	RT	Area %	Content %
Caproic acid	1.29	0.468	1.25
Caprylic acid	2.60	5.228	14.03
Capric acid	5.12	2.692	7.22
Lauric acid	8.61	18.862	50.62
Myristic acid	12.32	6.016	16.14
Palmitic acid	15.94	1.969	5.28
Stearic acid	19.94	0.512	1.37
Linoleic acid	20.45	0.230	3.30
Linolenic acid	21.83	0.287	0.77

Fig. 19 Chromatogram of variety Gangabondam x Laccadive Ordinary



Fatty acid	RT	Area %	Content %
Caproic acid	1.30	0.571	0.87
Caprylic acid	2.59	6.789	13.44
Capric acid	5.11	4.461	6.82
Lauric acid	8.60	29.993	45.85
Myristic acid	12.31	12.508	19.12
Palmitic acid	15.93	4.816	7.36
Stearic acid	19.92	0.974	1.49
Linoleic acid	20.43	2.644	4.04
Linolenic acid	21.82	0.652	1.00

Sanramon, Kappadam and Jamaica had contents above 2.2%. Malayan Yellow Dwarf had a low content of 0.90%.

Linoleic acid content ranged from 1.85 - 6.74% with a mean value of 4.40%. Variety Jamaica had the highest content of linoleic acid (6.74%) followed by Kappadam (6.32%). Keraganga had the lowest content of 1.85% followed by Malayan Yellow Dwarf (2.82%).

Linolenic acid was found in traces and ranged from 0.45% to 1.57% with a mean of 0.91%. Variety Keraganga had the lowest value (0.46%) and Jamaica the highest content of 1.57%. Varieties Lakshaganga, Sanramon and Kappadam had linolenic acid content above 1%.

4.2. Mineral nutrition in relation to oil content and quality parameters

An ongoing 3^3 confounded factorial experiment at the CRS. Balaramapuram, was utilised to find out the effect of mineral nutrition on the oil content and quality parameters of coconut oil. The results of the study are presented in the following pages with tables 5 to 9 and figures 5 to 8.

4.2.1 Effect of treatments on the oil content

The oil content of the different treatments ranged from 63 to 77%. The highest oil content of 77% was recorded in $N_1P_2K_0$ and the lowest of 63% in $N_1P_1K_0$ (Table 5). The oil content was not influenced by the main effects of N and P, but the main effect of K had a significant negative effect on the oil content (Table 6). Oil content was significantly high (71%) at the zero level of potassium, while the difference was only marginal at K_1 and K_2 levels (Fig. 5). Among the interactions, NP and PK interactions were significant, but NK interaction was not significant at all (Table 7). Nitrogen in combination with phosphorous at N_0P_2 level recorded a high oil content of 71.33%. The corresponding values for N_0P_0 and N_1P_1 are 67.67% and 69.67% respectively. Nitrogen in combination with phosphorous at N_1P_2 level showed a high oil content of 71.67% while the corresponding values for N_1P_0 and N_1P_1 are 68.67% and 66% respectively. Nitrogen in combination with phosphorous at the N_2P_2 level recorded a low value of 66.66% while the difference was not significant at N_2P_0 and N_2P_1 levels.

Considering the PK interaction at P_0 level of phosphorous, P_0K_0 recorded a high value for the oil content (72.33%). Treatments P_0K_1 and P_0K_2 did not differ significantly. In the combination of P_1 level of phosphorous with various levels of potassium, P_1K_0 showed the highest value of 70%. It then decreased to 66% in P_1K_1 and then increased to 69.33% in P_1K_2. In the combination of P_2 level of phosphorous, P_2K_2 recorded the lowest oil content of 68% whereas the combinations P_2K_1 and P_2K_2 were on a par.

4.2.2. Effect of treatments on acid value (A.V.)

The influence of NPK fertilizers on the A.V. was not significant (Fig. 6). The main effect as well as the interaction effects of N, P and K on the A.V. was found to be non significant (Table 6 & 7). However, the A.V. ranged from 0.40 to 3.35. The highest acid value was recorded in the treatment $N_2P_2K_2$ and the lowest in $N_1P_2K_1$ (Table 5).

4.2.3. Effect of treatments on saponification value (S.V.)

The S.V. of the different treatments ranged from 237.70 to 267.36. The highest value was recorded in the treatment $N_2P_0K_2$ and the lowest in $N_2P_2K_2$ (Table 5). S.V. of coconut oil was influenced by the main effects of N and K, but the main effect of P was significant (Table 6). Plots receiving zero level of P recorded a high S.V. of 261.08 (Fig. 7). It decreased to 256.18 in plots supplied with 225 g P per palm per year and to 256.18 in plots

Table 5. Effect of N,P and K on oil content and quality parameters of coconut.

Treatment	Oil Content %	Quality Parameters		
		Acid Value	Saponification Value	Iodine Value
$N_0P_0K_0$	69	0.52	252.24	10.32
$N_0P_0K_1$	68	0.52	259.01	7.14
$N_0P_0K_2$	66	1.11	259.82	8.26
$N_0P_1K_0$	72	1.90	252.48	10.19
$N_0P_1K_1$	65	1.50	261.45	8.39
$N_0P_1K_2$	72	1.06	256.69	7.33
$N_0P_2K_0$	69	0.56	259.44	6.10
$N_0P_2K_1$	76	0.73	245.99	9.14
$N_0P_2K_2$	69	2.53	257.47	8.94
$N_1P_0K_0$	75	0.08	256.58	4.81
$N_1P_0K_1$	65	0.54	261.81	5.98
$N_1P_0K_2$	66	0.83	266.02	5.58
$N_1P_1K_0$	63	1.08	243.36	7.89
$N_1P_1K_1$	68	0.55	261.29	6.95
$N_1P_1K_2$	67	0.56	257.55	6.04
$N_1P_2K_0$	77	0.02	242.39	6.08
$N_1P_2K_1$	71	0.40	249.98	8.77
$N_1P_2K_2$	67	0.42	262.43	7.22
$N_2P_0K_0$	73	0.42	260.93	8.54
$N_2P_0K_1$	67	0.51	266.00	5.35
$N_2P_0K_2$	68	0.67	267.36	8.04
$N_2P_1K_0$	75	1.57	265.06	7.19
$N_2P_1K_1$	65	0.69	249.72	7.90
$N_2P_1K_2$	69	0.40	257.98	7.09
$N_2P_2K_0$	66	0.95	252.57	4.47
$N_2P_2K_1$	65	1.60	260.48	10.25
$N_2P_2K_2$	68	3.35	237.70	8.76
Mean	68.93	0.93	256.44	7.51

Table 6. Main Effects of N,P and K on oil content and quality parameters of coconut.

Treatment	Oil Content %	Quality Parameters		
		Acid Value	Saponi-fication Value	Iodine Value
N_0	69.55	1.05	256.07	8.42
N_1	68.78	0.72	255.71	6.59
N_2	68.44	1.13	257.53	7.51
P_0	68.56	0.69	261.08	7.11
P_1	68.44	0.92	256.18	7.66
P_2	69.77	1.29	252.05	7.75
K_0	71.00	0.11	253.89	7.29
K_1	67.78	0.67	257.30	7.76
K_2	68.00	1.22	258.11	7.47
CD	1.89	----	6.04	----

Table 7 : Effect of two factor interactions of N, P and K on oil content and quality parameters.

Treatment	Oil Content %	Quality parameters		
		Acid Value	Saponification Value	Iodine Value
N_0P_0	67.67	0.72	257.02	8.57
N_0P_1	69.67	1.15	256.87	8.64
N_0P_2	71.33	1.27	254.30	8.06
N_1P_0	68.66	0.82	261.47	5.45
N_1P_1	66.00	0.73	254.07	6.96
N_1P_2	71.67	0.61	251.60	7.36
N_2P_0	69.33	0.54	264.76	7.31
N_2P_1	69.67	0.89	257.59	7.39
N_2P_2	66.33	1.97	250.25	7.83
N_0K_0	70.00	0.99	254.72	8.87
N_0K_1	69.67	0.59	255.49	8.22
N_0K_2	69.00	1.57	257.99	8.18
N_1K_0	71.67	1.06	247.44	6.26
N_1K_1	68.00	0.50	257.69	7.23
N_1K_2	66.67	0.60	261.10	6.28
N_2K_0	71.33	0.98	259.52	6.73
N_2K_1	65.67	0.93	258.73	7.84
N_2K_2	68.33	1.47	254.35	7.96
P_0K_0	72.33	0.67	256.58	7.89
P_0K_1	62.67	0.53	262.27	6.16
P_0K_2	62.67	0.87	264.40	7.29
P_1K_0	70.00	1.52	253.63	8.42
P_1K_1	66.00	0.58	257.49	7.75
P_1K_2	69.33	0.67	257.41	6.82
P_2K_0	70.67	0.84	251.47	5.55
P_2K_1	70.67	0.91	252.15	9.39
P_2K_2	68.00	2.10	252.53	8.31
CD	3.28	----	----	2.58

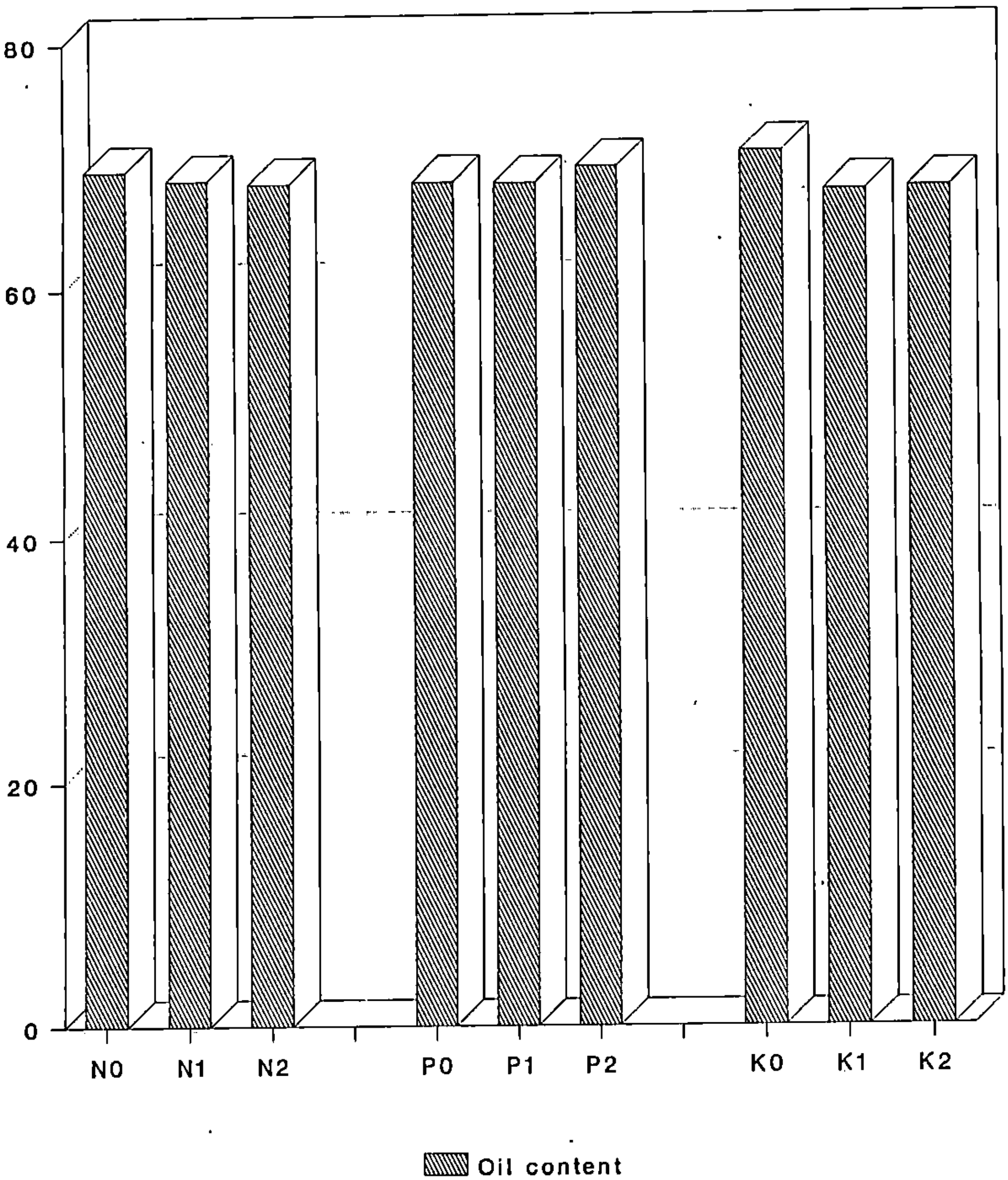


Fig. 5. Main effect of N, P and K on oil content of coconut

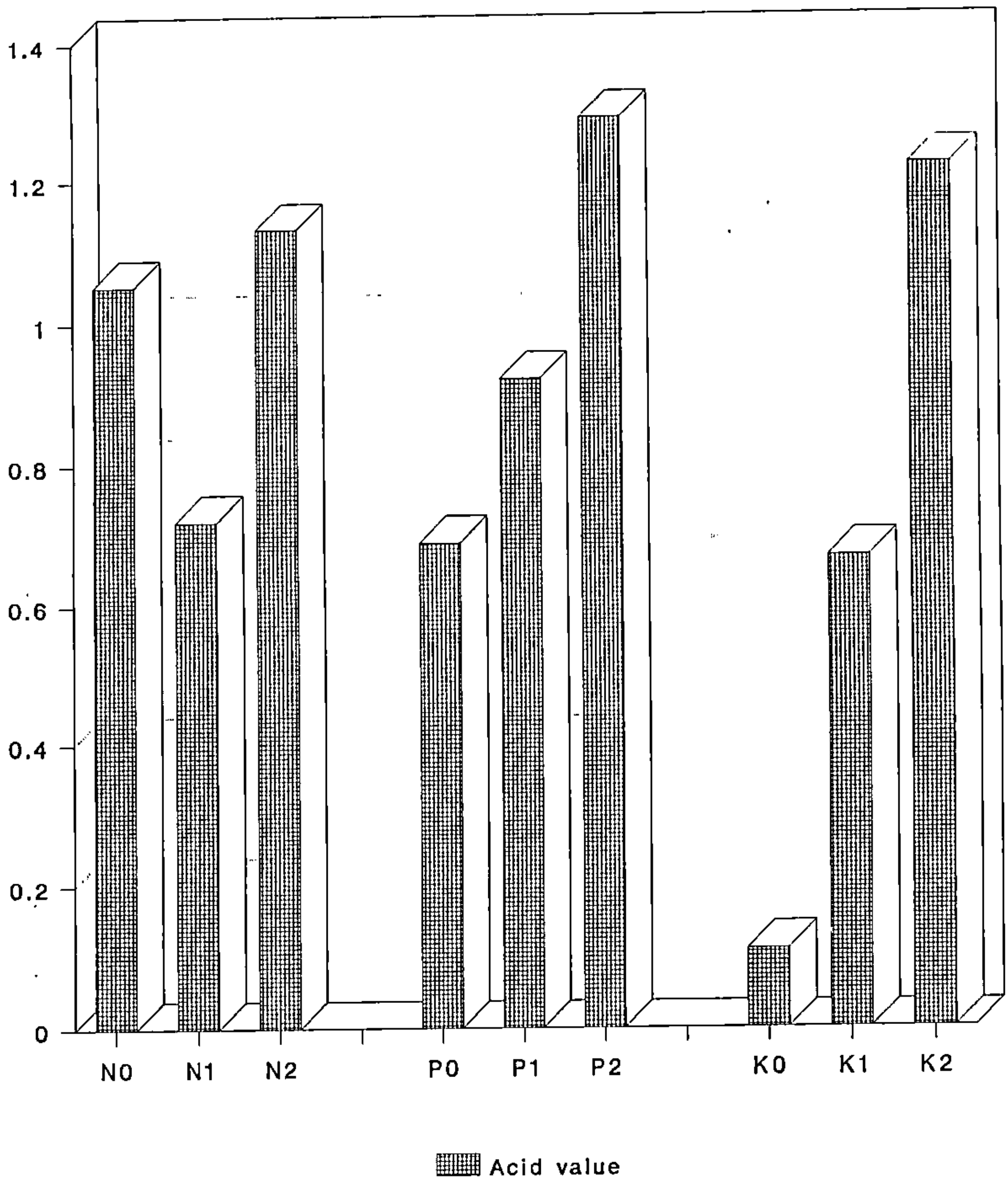


Fig. 6. Main effect of N, P and K on acid value of coconut

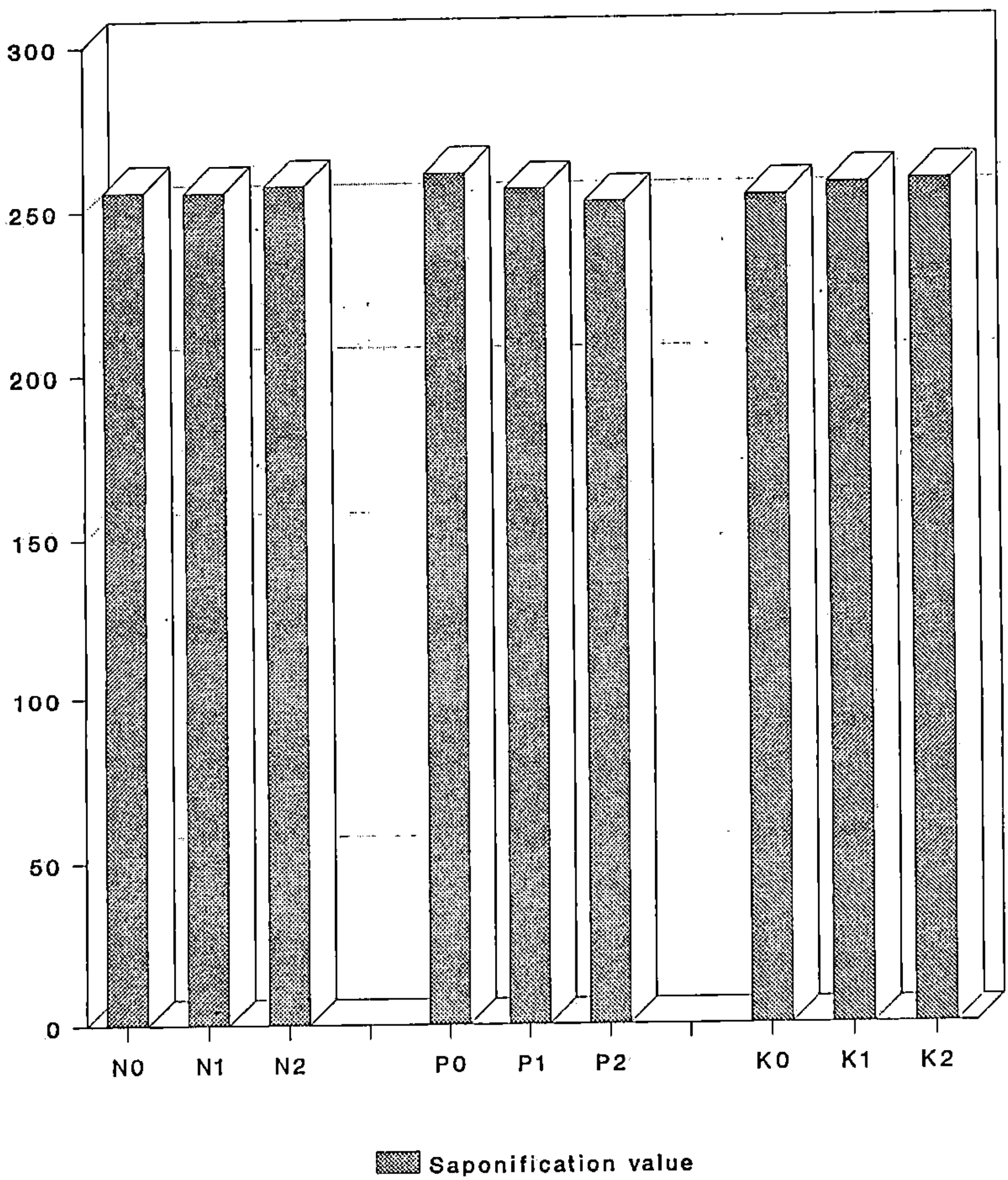


Fig. 7. Main effect of N, P and K on saponification value of coconut

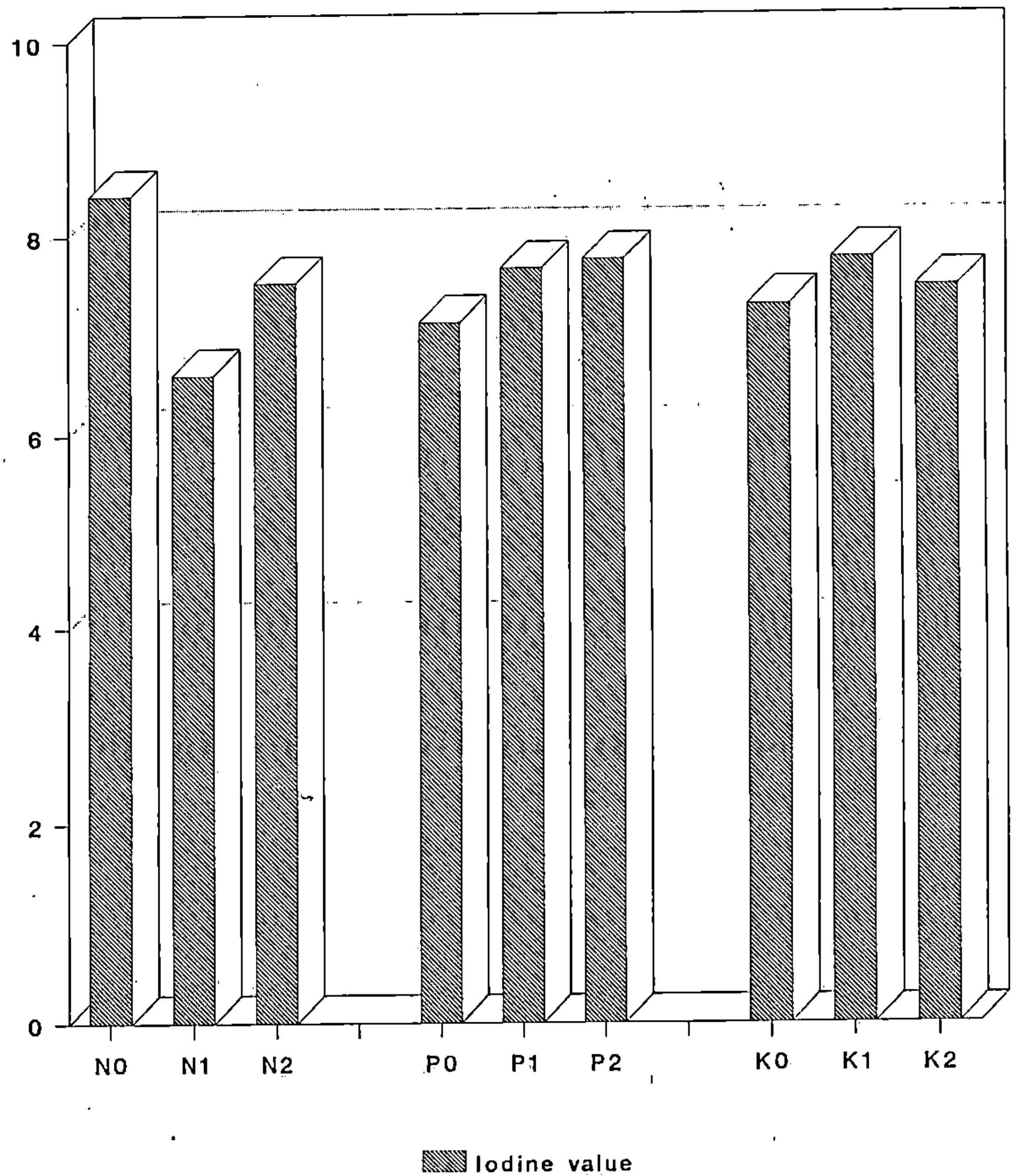


Fig. 8. Main effect of N, P and K on iodine value of coconut

supplied with 450 g `P' per palm per year. The interaction effects were also found to be non significant (Table 7).

4.2.4 Effect of treatments on iodine value (I.V.)

The iodine value of the different treatments ranged from 4.47 to 10.32. The highest value of 10.32 was registered in the treatment $N_0P_0K_0$ and the lowest value in $N_2P_2K_0$ (Table 5). The I.V. of coconut oil was not influenced by the main effects of N, P and K (Table 6 and Fig. 8). Among the interactions only PK was found to be significant (Table 7). In the combination of various levels of potassium, at the P_0 level of phosphorus not much significance was observed. At P_1 level, the iodine value decreased linearly from P_1K_0 (8.42) to P_1K_2 (6.82). The lowest iodine value at P_2 level of phosphorus was recorded by P_2K_0 (5.55), while P_2K_1 and P_2K_2 showed only a marginal difference.

4.2.5. Effect of treatments on Reichert - Meissel value (R.M.) and Polenske value (P.V.)

The R.M. values obtained for the various treatments for Replication I are presented in Table 8. There was a slight variation in the values ranging from 8.10

Table 8. Effect of N,P and K on Reichert-Meissel(R.M.) and Polenske values (P.V.)

Treatment	R.M.Value	P.Value
N0P0K0	8.97	16.06
N0P0K1	9.90	15.29
N0P0K2	8.58	18.92
N0P1K0	9.35	17.71
N0P1K1	9.46	18.26
N0P1K2	10.34	17.93
N0P2K0	9.46	11.44
N0P2K1	9.90	17.49
N0P2K2	9.46	14.96
N1P0K0	10.12	18.26
N1P0K1	8.64	16.26
N1P0K2	9.79	16.72
N1P1K0	8.25	17.49
N1P1K1	9.68	17.05
N1P1K2	9.90	17.38
N1P2K0	9.90	16.83
N1P2K1	10.45	19.14
N1P2K2	9.57	17.82
N2P0K0	9.13	21.23
N2P0K1	8.47	17.05
N2P0K2	8.80	16.72
N2P1K0	9.90	16.72
N2P1K1	8.80	16.17
N2P1K2	11.11	18.37
N2P2K0	9.67	16.48
N2P2K1	9.79	17.38
N2P2K2	8.10	18.48
Mean	9.46	17.17

to 11.11. The highest value was recorded in the treatment $N_2P_1K_2$ and the lowest value in $N_2P_2K_2$.

The P.V. obtained for the different treatments for Replication I are presented in Table 8. There was variation among the values ranging from 11.44 to 21.23. The highest P.V. was registered in $N_2P_0K_0$ and the lowest in $N_0P_2K_0$.

4.2.6. Effect of treatments on the fatty acid composition

The oil from the selected treatments which were subjected to gas liquid chromatography showed considerable variation in the fatty acid composition (Fig. 20-24). The distribution pattern of fatty acids showed that saturated fatty acids varied from 94.08% to 97.54% while unsaturated fatty acids ranged from 1.78% to 5.92%. Lauric acid (C12:0) was the dominant among the saturated fatty acids (Table 9).

Caproic acid content ranged from 1.11% to 2.11%. $N_2P_2K_2$ recorded the lowest value (1.11%) and $N_2P_0K_0$ the highest value (2.11%). Highest dose of K ($N_0P_0K_2$) recorded a value of 1.94%. Caprylic acid content was highest in the treatment $N_2P_2K_2$ (22.35) and lowest in $N_0P_0K_2$ (1.12%). Treatment $N_0P_0K_2$ recorded the highest content of capric acid followed by $N_2P_0K_0$ and $N_0P_2K_0$. The lowest content was seen in $N_2P_2K_2$.

Table 9: Fatty Acid Composition of Selected Treatments

Treatments	Caproic acid $C_6:0$	Caprylic acid $C_8:0$	Capric acid $C_{10}:0$	Lauric acid $C_{12}:0$	Myristic acid $C_{14}:0$	Palmitic acid $C_{16}:0$	Stearic acid $C_{18}:0$	Linoleic acid $C_{18}:1$	Linolenic acid $C_{18}:2$
$N_2P_2K_2$	1.11	22.25	7.81	45.60	13.90	5.09	0.96	2.91	0.30
$N_0P_0K_0$	1.47	17.62	9.57	51.78	12.82	3.56	0.68	1.89	0.60
$N_2P_0K_0$	2.11	14.78	11.75	33.42	19.31	6.24	1.47	4.59	1.32
$N_0P_2K_0$	1.72	19.05	10.22	52.04	11.50	2.93	0.65	1.78	0.57
$N_0P_0K_2$	1.94	1.12	11.84	62.10	15.28	4.16	0.66	2.29	0.65

Lauric acid was the dominant acid. The highest content was seen in $N_0P_0K_2$ (62.10%) followed by $N_0P_2K_0$ (52.04%) and $N_0P_0K_0$ (51.78%). The lowest content was registered in $N_2P_0K_0$ (38.42%).

Myristic acid content from 11.50% to 19.31%. Treatment $N_2P_0K_0$ recorded the highest value and $N_0P_2K_0$ the lowest value. The other treatments had intermediate values.

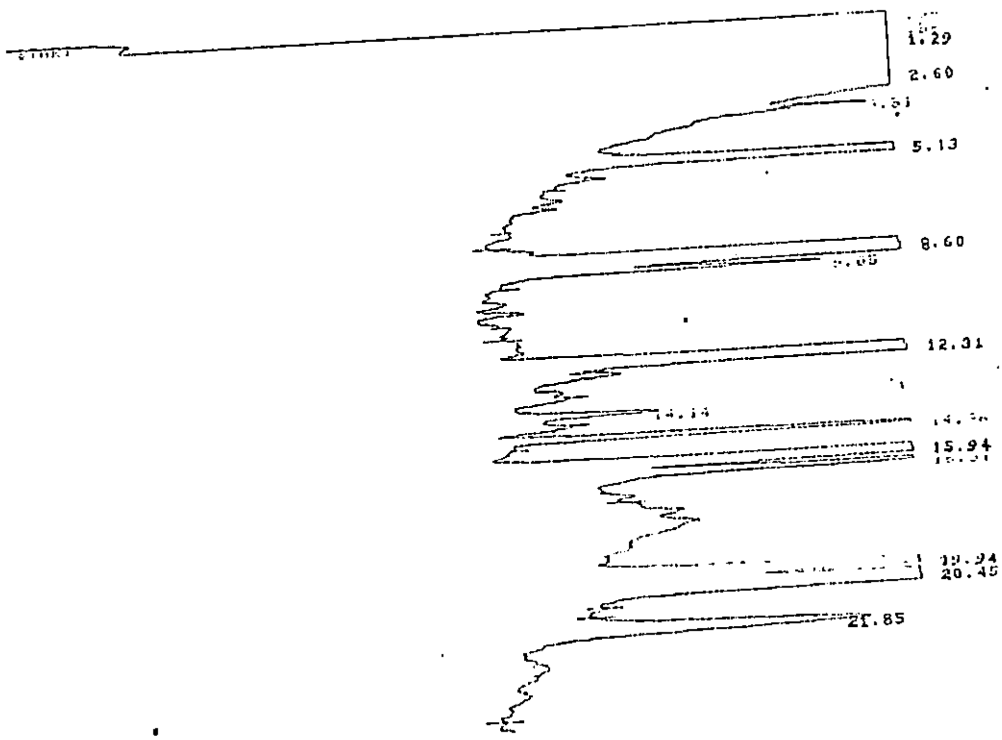
Highest dose of N registered the highest content of palamitic acid (6.24%). Treatment $N_0P_2K_0$ had the lowest percentage (2.93%).

Stearic acid content ranged from 0.65% to 1.47%. Highest content was registered in the treatment with the highest content of Nitrogen ($N_2P_0K_0$) and the lowest in $N_0P_2K_0$. All the other treatments had lower values ranging from 0.66% to 0.96%.

Linoleic acid content registered highest value in the treatment $N_2P_0K_0$ (4.59%) and the lowest in $N_0P_2K_0$ (1.78%). Treatment $N_2P_2K_2$ recorded a value of 2.91%.

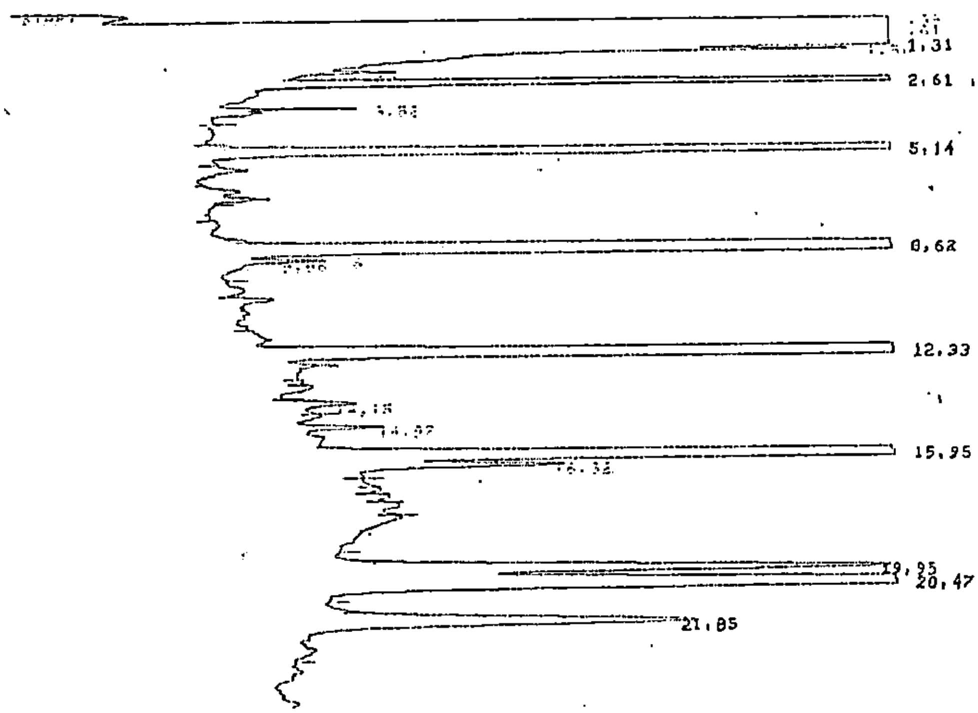
Linolenic acid (C18:2) was seen only in traces. Only treatment $N_2P_0K_0$ recorded a content above 1% (1.32%). The linolenic acid content was the least in $N_2P_2K_2$.

Fig. 20 Chromatogram of treatment $N_2P_2K_2$



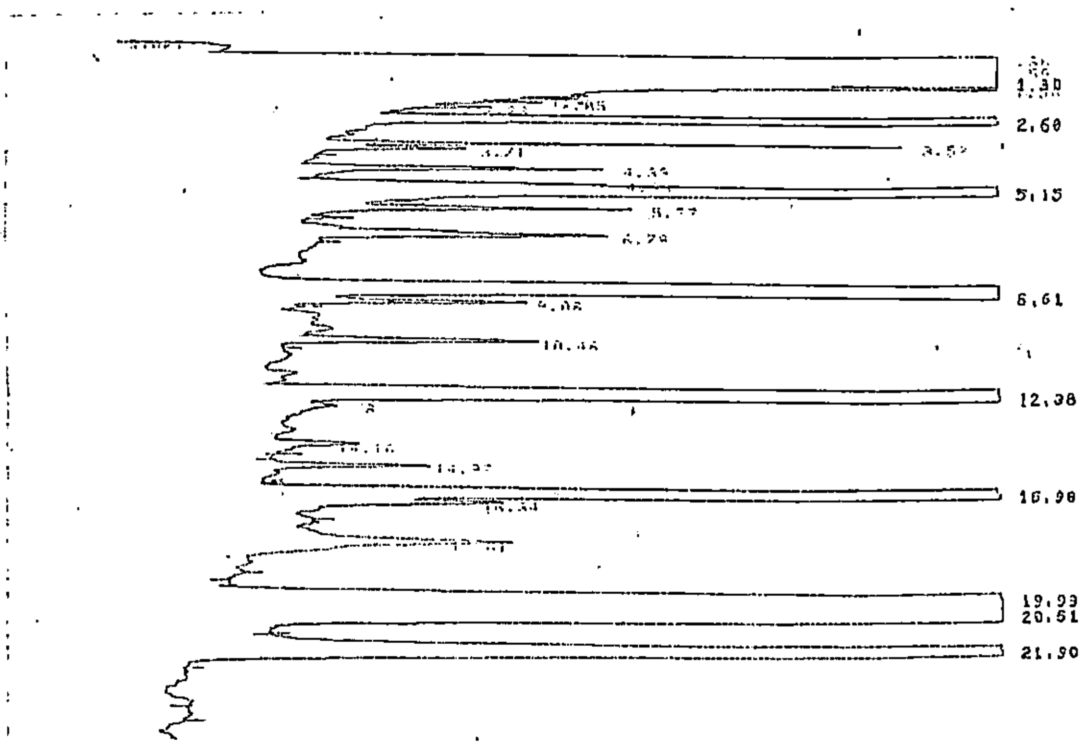
Fatty acid	RT	Area %	Content %
Caproic acid	1.29	0.254	1.11
Caprylic acid	2.60	5.122	22.35
Capric acid	5.13	1.783	7.81
Lauric acid	8.60	10.448	45.60
Myristic acid	12.31	3.186	13.90
Palmitic acid	15.94	1.166	5.09
Stearic acid	19.94	0.219	0.96
Linoleic acid	20.45	0.667	2.91
Linolenic acid	21.85	0.069	0.30

Fig. 21 Chromatogram of treatment $N_0P_0K_0$



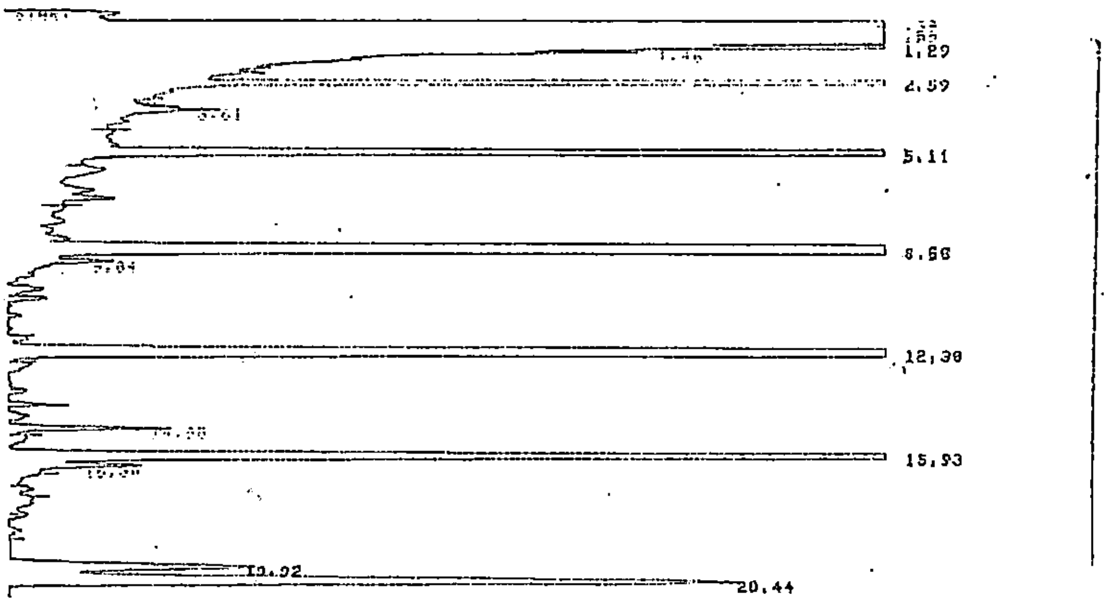
Fatty acid	RT	Area %	Content %
Caproic acid	1.31	0.603	1.47
Caprylic acid	2.61	7.218	17.62
Capric acid	5.14	3.921	9.57
Lauric acid	8.62	21.211	51.78
Myristic acid	12.33	5.253	12.82
Palmitic acid	15.95	1.458	3.56
Stearic acid	19.95	0.280	0.68
Linoleic acid	20.47	0.776	1.89
Linolenic acid	21.85	0.246	0.60

Fig. 22 Chromatogram of treatment $N_2P_0K_0$



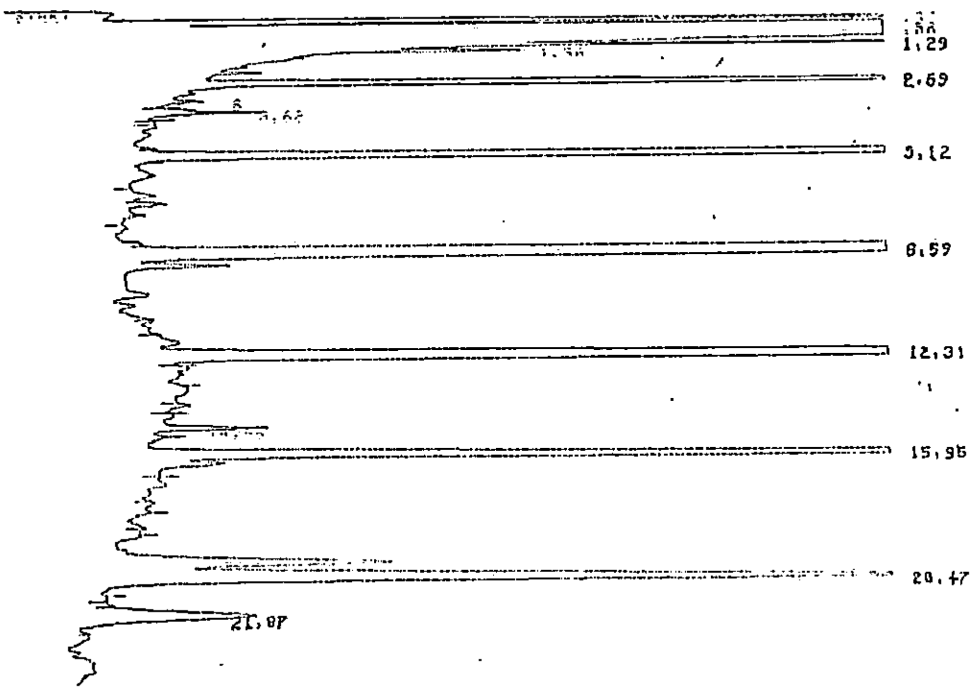
Fatty acid	RT	Area %	Content %
Caproic acid	1.30	1.429	2.11
Caprylic acid	2.60	10.022	14.78
Capric acid	5.15	7.968	11.75
Lauric acid	8.61	26.051	38.42
Myristic acid	12.38	13.098	19.31
Palmitic acid	15.98	4.232	6.24
Stearic acid	19.99	0.999	1.47
Linoleic acid	20.51	3.116	4.59
Linolenic acid	21.90	0.897	1.32

Fig. 23.1 Chromatogram of treatment $N_0P_2K_0$



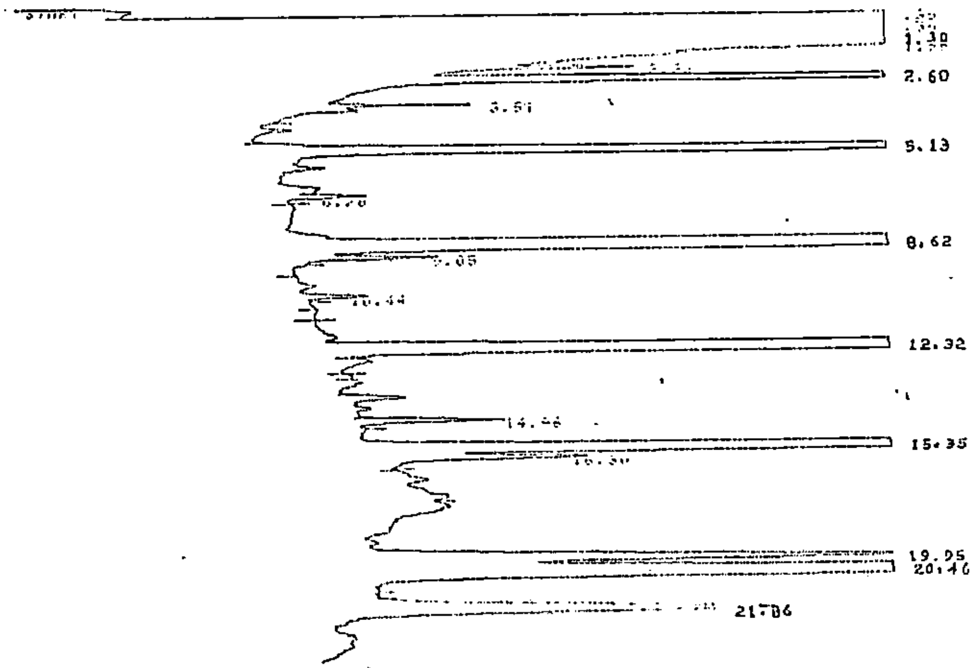
Fatty acid	RT	Area %	Content %
Caproic acid	1.29	0.541	1.72
Caprylic acid	2.59	6.001	19.05
Capric acid	5.11	3.250	10.32
Lauric acid	8.58	16.392	52.04
Myristic acid	12.30	3.623	11.50
Palmitic acid	15.93	0.923	2.93
Stearic acid	19.92	0.204	0.65
Linoleic acid	20.44	0.562	1.78
Linolenic acid			

Fig. 23.2 Chromatogram of treatment $N_0P_2K_0$



Fatty acid	RT	Area %	Content %
Caproic acid	1.29	0.394	1.56
Caprylic acid	2.59	4.344	17.22
Capric acid	5.12	2.369	9.39
Lauric acid	8.59	13.083	51.85
Myristic acid	12.31	3.367	13.34
Palmitic acid	15.95	0.973	3.86
Stearic acid			
Linoleic acid	20.47	0.557	2.21
Linolenic acid	21.87	0.145	0.57

Fig. 24 Chromatogram of treatment $N_0P_0K_2$



Fatty acid	RT	Area %	Content %
Caproic acid	1.30	0.717	1.94
Caprylic acid	2.60	8.416	1.12
Capric acid	5.13	4.384	11.84
Lauric acid	8.62	22.988	62.10
Myristic acid	12.32	5.637	15.23
Palmitic acid	15.95	1.541	4.16
Stearic acid	19.95	0.244	0.66
Linoleic acid	20.46	0.848	2.29
Linolenic acid	21.86	0.241	0.65

DISCUSSION

5. DISCUSSION

The results obtained in the present investigation to find out the effect of varietal variation and mineral nutrition on the oil content, quality parameters and fatty acid composition of coconut oil are discussed here under.

5.1. Varietal variation in relation to oil content and quality parameters.

Experimental results from the present investigation obtained are discussed below to assess the role of varieties/cultivars and the interaction of varietal characters with the environment and the fertility status of the soil. The data is further utilized to derive valuable information about the quality parameters and fatty acid composition of coconut oil.

The experimental data collected from the review of literature on the above aspects are still few and the results available do not permit the formulation of any general hypothesis. However, the investigations envisaged in this study has enabled to arrive at certain general conclusions noticeably on the oil content, quality of the oil and fatty acid composition. Reports by many scientists have pointed out that the above factors are so controlled by genetic factors to be almost insensitive to environmental conditions (Appelqvist, (1977); Ochs (1977) and Nambiar and Rao (1988)). Thus the genetic make up of variety/cultivar is very important in deciding the above aspects. The data obtained are thus discussed keeping in mind the above view reported from many prestigious research centers working on coconut.

5.1.1. Oil content

In the present study significant difference in the oil content was observed among the 24 varieties of coconut collected from the RARS, Pilicode and the Instructional Farm, Vellayani (Appendix I). General variation in the oil content was 60-78% (Table 1). The variety Komadan recorded the highest oil content of 78% followed by Cochin China and Sanramon (73%). The lowest value in the oil content of 60% was recorded in the case of Malayan Dwarf Orange. Varieties Jamaica, West Coast Tall and the hybrid Fiji x Gangabondam had oil contents above 70%. A close scrutiny of the data reveals that tall varieties/cultivars in general are better yielders of coconut oil when compared to hybrids and dwarfs (Fig. 1). Earlier studies on the effect of varietal variation in yield, nut characters, copra and oil content also revealed distinct differences in these parameters among the varieties (Pillai and Satyabalan, 1960; Satyabalan and Mathew, 1984; Rao and Nair, 1986 and Nambiar and Rao, 1988). Results of the present study are in conformity with the reports of Louis and Ramachandran (1981) who observed high oil content in tall varieties. Further their studies have pointed out that dwarf varieties are poor yielders of coconut oil with the hybrids coming intermediate (Tall varieties - 64.3 - 77.2%, Dwarfs - 54 - 68% and hybrids - 64.7 - 70.2%). Similar observations have been reported by Mandal, (1991) and Reddy *et al.* (1981) in coconut varieties. In addition to the exhaustive root system covering larger volume of soil matrix, the innate capacity to survive under adverse soil and environmental stress conditions coupled with the enormous capacity of trunk storage of nutrients may be attributed to the higher yield of coconut oil from tall varieties when compared to the dwarfs and hybrids.

Oil content of another 20 varieties collected from the R.A.R.S. Pilicode , (without replication) also showed considerable variation (Table 2). Varieties Gonthembli, Laccadive Ordinary and Laccadive Dwarf recorded higher values for oil content (76%). Andaman Dwarf recorded gave the lowest oil percentage (50%). Among the tall varieties Andaman Ordinary, Ayiramkachi and Benza hybrid recorded an oil content of 70% and Spicata another tall variety registered an oil content of 72%. In this observation also tall varieties are found to be better oil yielders followed by hybrids and dwarfs.

5.1.2. Acid value

Statistical analysis of the data obtained for acid value reveals, significant effect due to varietal variation (Appendix II). The values ranged from 0.71 to 5.44 in the case of first set of samples subjected to statistical analysis and from 0.53 to 7.56 in the second case of 20 varieties without replication. In the first set of samples subjected to statistical analysis, variety Chowghat Green Dwarf recorded the lowest A.V. of 0.71 and variety Java the highest value of 5.44. In the second category of 20 varieties without replication, Natural Cross Dwarf recorded the lowest value (0.53) and the hybrid Andaman Ordinary x Chowghat Orange Dwarf registered the highest (7.56) (Table 2). Since A.V. is a measure of the free fatty acid content of the oil which is subjected to changes depending on conditions like lipase activity, peroxide activity, oxidative and hydrolytic rancidity; storage conditions and time intervals between extraction and sampling also should be taken into consideration before making a judgment about this quality parameter in relation to varietal variation. As on today, the review of literature does not give any conclusive evidence to make a judgment about the dependence of A.V. on varietal variation. Results of the study conducted on oils of other crops like sesamum have shown the nondependence of this quality parameter on genetic variation (Tyagi and Vasishtha, 1983). Further, in the present study also perfect uniformity in time intervals between oil extraction and determination of the A.V. could not be adhered to due to various limitations in the laboratory facilities. However, all the samples extracted were subjected to A.V. analysis within the shortest possible time interval.

Thus the chances of varietal variation influencing this quality parameter cannot be ruled out, though not supported hitherto from elsewhere. Though a generalisation based on varietal characters is difficult for A.V., it is evident from the study that tall varieties with high iodine value give higher acid values too. Detailed studies are to be initiated to have a deeper insight of this aspect.

5.1.3. Saponification value (S.V.)

Among the varieties subjected to investigation, Keraganga a hybrid variety recorded the highest S.V. of 264.53 followed by West Coast Tall with 263.19 (Table 1). Lowest S.V. was recorded in Malayan Dwarf Orange (221.83). Effect of varietal variation on S.V. was found to be highly significant (Appendix III). An increase in S.V. is obviously due to an increase in the content of short chain fatty acids. This is clearly evident from the fatty acid composition of some of these varieties which recorded high S.V. (Table 4). Variety Keraganga and West Coast Tall with high S.V. recorded higher percentages of C8:0 and C10:0 fatty acids (19.64% and 10.26% for Keraganga and 15.41% and 9.79% for West Coast Tall respectively) thus giving indirect evidence in support of the observation. Varieties Malayan Dwarf Yellow, Malayan Dwarf Orange and Thembli had low S.V. in the range of 221.83 to 227.33. Varieties Cochin China, Kappadam, Navasi, Philippines, Siam and Lakshaganga had S.V. greater than 260.

Saponification value of another 20 varieties collected from the RARS. Pilicode, without replication also showed considerable variation. Spicata, a tall variety recorded the highest S.V. of 268.80. Lowest value was recorded in West Coast Tall x Laccadive Dwarf (240.80). Tall varieties Mysore, New Guinea, Ceylon and Ayiramkachi had S.V. greater than 260. Among the dwarf varieties, Natural Cross Dwarf registered the highest S.V. of 266.13 followed by Laccadive Ordinary (263.36). The higher content of short chain fatty acids of Laccadive Ordinary as revealed from the fatty acid profile (Table 4) indirectly supports its higher S.V. (13.85% and 8.01% of C8:0 and C10:0 acids). Hybrids Cochin China x Chowghat Orange Dwarf recorded a S.V. of 268.80 followed by Kerasree (266.13). These results are also in support of the earlier observation.

5.1.4. Iodine value (I.V.)

Iodine value of the varieties subjected to investigation ranged from 4.09 to 11.66 (Table 1) in the case of replicated samples subjected to statistical analysis. Highest I.V. was recorded in variety Jamaica (11.66) followed by Java (10.46), Siam (10.19) and Lakshaganga (10.17). Some of the hybrids have shown iodine values higher than their parents as in Lakshaganga(Laccadive Ordinary x Gangabondam). The effect of varietal variation on the I.V. was highly significant (Appendix IV). The effect of genetic architecture influencing the I.V. has been reported by many workers in the case of oil palm, rape seed and linseed, though the same has not been observed and reported in the case of coconut (Arnon (1977) in oil palm and rape seed; Bajpai et al. (1985) in linseed). Studies conducted by Gascon and Wuidart (1975); Mustafa and Sjafrul, (1984) and Goh and Timms, (1987) in oil palm have studied the influence of varietal variation on the content of unsaturated fatty acids and observed higher values for hybrids than their parents. Another study on oil palm had given values for polyunsaturated fatty acids intermediary of the parents [Hardon, (1968) and Nouret and Wuidart, (1976)].

A close scrutiny of the data reveals a decrease in I.V. and hence the content of unsaturated fatty acids in the order tall followed by hybrids and dwarf. Tall varieties Jamaica, Java and Siam had higher I.V. than dwarf varieties Gangabondam, Malayan Dwarf Yellow and Malayan Dwarf Orange. Both tall and hybrids gave much higher I.V. than dwarf varieties. This observation is further supported by the data on fatty acid composition as evidenced from gas liquid chromatographic analysis (Table 4). Jamaica the tall variety, which gave the highest I.V. had given the highest content of linoleic and linolenic acids. (6.74% and 1.57% respectively). Lakshaganga, a well known hybrid with an I.V. of 10.17 had given 5.99% of linoleic and 1.38% of linolenic acid which substantiated the high iodine values thus obtained . Malayan Yellow Dwarf, a true representative of dwarf variety with low I.V. had given low values for linoleic and linolenic acid content on fractionation (2.82% and 0.56% respectively).

Varieties without replication also had shown wide variations in the I.V. ranging from 4.44 to 13.33 (Table 2). Andaman Guinea a tall variety recorded the highest I.V. (13.33) and Benza hybrid the lowest (4.44). Laccadive Dwarf recorded a low I.V. of 6.58. Among the hybrids Andaman Ordinary x Chowghat Orange Dwarf gave a high I.V. of 12.70

followed by Kerasree another well known hybrid (11.11).

Thus, it is evident from the foregoing discussions that the content of mono and poly unsaturated fatty acids of coconut oil is also influenced to a greater extent by varietal variation.

5.1.5. Reichert - Meissel (R.M.) and Polenske Value (P.V.)

These two quality constants are indicative of the short chain fractions of the oil. The R.M. value of the selected 28 varieties ranged between 7.70 to 10.67 whereas the range for P.V. was 14.63 to 18.50 (Table 3). Though these are minor quality constants with respect to coconut oil, variations in their values are indicated in the present investigation due to varietal differences. In general, tall varieties recorded higher values for R.M. and P.V. than hybrids and dwarfs. Tall variety Jamaica had a high value of 10.23 followed by Siam (10.01), West Coast Tall(9.90) and Ceylon (9.90). Data on fatty acid composition as indicated by fractionation studies also had given higher contents of short chain fatty acids like C6 and C8 for those varieties with comparatively higher R.M. values (Table 4). However, the observations are not true for all the varieties that are fractionated. This is supposedly due to the variation in the percentages of the other short chain fatty acids that were not obtained in the chromatogram (C4:0). Further, the distinction boundary of fatty acids as water soluble and water insoluble but alcohol soluble is not very sharp. Thus the border line members can overlap and will contribute to both R.M. value and P.V. Fiji, a tall variety recorded a high P.V. of 18.5. The average Polenske values were 16.69, 15.87 and 15.86 for tall, dwarf and hybrids respectively.

It is thus clear from the afore discussed that varietal variation is reflected even in R.M. value and P.V. though not statistically tested. A detailed investigation with more replications supported by fractionation of the oil from all the samples covering all the varieties studied will throw additional information on this aspect. Hitherto no information has been reported from elsewhere relating genetic variability of coconut with the R.M. value and P.V. of its oil.

5.1.6. Fatty acid fractionation

Data on the fatty acid composition of 11 selected varieties had given considerable variations in their percentages upon fractionation (Fig. 9-19). The percentage of saturated fatty acids varied from 91.70% to 97.70% with an average of 94.69% while unsaturated fatty acid content ranged from 2.30% to 8.30% with a mean value of 5.30%. The highest saturated to unsaturated fatty acid ratio was observed in the variety Keraganga (42.44) and the lowest value in Jamaica (11.04). Among saturated fatty acids, lauric acid (C12:0) registered the highest percentage (43.26%) followed by myristic acid (C14:0) (18.83%). Caproic acid (C6:0) had given the lowest value among the saturated fatty acids. Values for Caprylic (C8:0), Capric (C10:0) Palmitic (C16:0) and stearic (C18:0) were intermediate. Thus it is clear from the data that coconut oil is rich in short and medium chain fatty acids as compared to long chain fatty acids. The results are in conformity with similar results obtained by Rao and Srinivasa, (1981).

Among unsaturated fatty acids, linoleic acid (C18:1) recorded the highest value followed by linolenic acid (0.91%). Out of the 11 selected varieties the highest linoleic acid (C18:1) content was recorded in the variety Jamaica (6.74%) followed by Kappadam (6.32%). The lowest value of 1.85% was registered in the case of Keraganga. In the case of linolenic acid which is a poly unsaturated fatty acid, the values ranged from 0.45 - 1.6%. Similar variations in fatty acids content (both saturated and unsaturated) had been reported by Rao and Srinivasa, (1981) in coconut, groundnut, sesame, sunflower and mustard oil.

Further, such variations has been reported in oil palm also by Hartley (1977), Majnu and Sjafrul, (1984) and Goh and Timms (1987).

Thus it is evident from the foregoing discussion that varietal variation can cause differences in the content of both saturated and unsaturated fatty acids in the case of coconut. However, variations observed were not statistically tested as the number of oil samples fractionated were few. A detailed investigation with more number of varieties and replication is required to make a generalisation.

5.2. Mineral nutrition in relation to oil content and quality parameters

While considerable attention has been paid by research workers to study the effect of fertilizers on the yield of oil crops, information regarding their effects on oil content and its quality is still inadequate and fragmentary. To have a deeper insight of this aspect on coconut oil an ongoing 3^3 confounded factorial experiment at CRS, Balaramapuram was utilised. The data obtained on oil content, quality parameters and fatty acid composition of the oil are discussed below in relation to the effect of fertilizers.

5.2.1. Oil content

Oil content of the different treatments ranged from 63 to 77% (Table 5). The highest oil content of 77% was recorded in $N_1P_2K_0$ and the lowest of 63% in $N_1P_1K_0$. The oil content was not influenced by the main effects of N and P, but K had a significant but negative effect (Appendix V). The oil content was significantly high, 77% at the zero level of K while the difference was only marginal between K_1 and K_2 (Fig.5). Thus the present study is not in conformity with the reports of Pushpangadan (1985) who found a significant effect of K at all levels. However Romney (1972) observed no significant difference in oil content due to variations in the dose of K. As the present study has not taken into account the copra and oil yield per nut, the effect of K fertilization on oil yield could not be obtained. Oil content expressed in percentage is not affected though the oil yield per nut is likely to be affected. Thus, the effects of NPK fertilization was found to be very important in deciding the total biomass production including oil yield but remains insignificant in changing the oil percentage. As there are ample reports [Ochs and Ollagnier, (1977) and Pushpangadan, (1985)] to substantiate the nutritional role of N, P and K in increasing the oil and copra yield per nut, the purpose of this study was to investigate the role of mineral nutrition on oil quality and fatty acid composition. Reports of Appelqvist, (1977) and Ochs and Ollagnier, (1977) who observed no significant effect for fertilizers on oil content (percentage) of oil seeds is thus in conformity with the results of the present study.

The interaction effects of nitrogen and phosphorous as well as potassium and phosphorus was found to be significant. Thus, indirectly the nutritional effect of all the treatments are important. However, the lowest dose of P with the lowest dose of K and the second dose of N with the highest dose of P had given the maximum oil content in PK and NP interactions. Thus the nutritional role of N, P and K is less significant in deciding the oil content(percentage) of copra, though the total yield in terms of copra and oil per nut is affected by the same.

5.2.2. Quality parameters

The influence of NPK fertilizers on quality parameters like acid value (A.V.), saponification value (S.V.) and iodine value (I.V.) was not significant in general (Appendices VI, VII & VIII). However, a negative significant effect was found in the case of P nutrition with respect to S.V. as the plots receiving zero level of P recording a high S.V. (Table 6). This information is in conformity with the reports of Ochs and Ollagnier (1977) who observed no noticeable change in the oil quality due to fertilizer treatments.

This non dependance of the quality parameters on fertilizer treatments is attributed to the complete overshadowing of these effects by the changes in oil composition that occurs during processing (Crawford,1977). Further there are reports in support of the view that the chemical composition and quality of oil is more influenced by genetic variability than fertilizer effects. The composition of the oil and hence the quality parameters in general remains more or less the same irrespective of changes in the nutritional status, in whatever magnitude be the nutrient availability changes. Thus, from the aforementioned discussion and the data presented, it is clear that the direct effects of fertilizers on oil content and quality appears to be negligible when compared to varietal variation and hence there is no point in endeavouring to influence oil quality by fertilization.

Results obtained for Reichert Meissel (R.M.) and Polenske values (P.V.) have shown variation due to fertilizer treatments though not statistically tested. The variation was marginal in the case of R.M. Value from 8.10 to 11.11 but was substantial in the case of P.V. (11.44) to 21.23). The lowest P.V. was recorded in the treatment

$N_0P_2K_0$ and the highest in $N_2P_0K_0$. The data generated through this investigation is not sufficient enough to make any generalisation on the effect of mineral nutrition in relation to R.M. and Polenske values. A detailed investigation with more number of samples taken from all the treatments and the result subjected to statistical analysis alone could give a conclusive information of these parameters.

5.2.3. Fatty acid fractionation

Data on the fatty acid fractions of random samples taken to study the fatty acid composition of coconut oil due to mineral nutrition had given considerable variations in their percentages (Fig. 20-24). The percentage of saturated fatty acids varied from 94.08% to 97.54% while unsaturated fatty acids ranged from 1.78% to 5.92%. The highest saturated to unsaturated fatty acids ratio was observed in the treatment $N_0P_2K_0$ (41.63) and the lowest in $N_2P_0K_0$ (16). Among the saturated fatty acids, lauric acid (C12:0) registered the highest percentage in all the treatments and caproic acid (C6:0) the lowest value. The highest percentage of lauric acid and linoleic was recorded in the treatment with the highest dose of [K and] N. The lowest content of linoleic acid was recorded in the treatment with the highest dose of P. Linolenic acid (C18:2) was found to be highest in the treatment $N_2P_0K_0$ (41.63) and the lowest in $N_2P_2K_2$ (Table 9).

Thus, it is evident from the above discussion that mineral nutrition can cause variation in the fatty acid composition of coconut oil. However, variations observed were not statistically tested as the number of samples taken were at random and few. Reports of Ochs and Ollagnier (1977) who observed variation in the fatty acid composition of palm oil due to mineral nutrition is thus in conformity with the results of the present study. A detailed investigation with samples taken from all the treatments and more number of replications are required to arrive at a generalisation.

SUMMARY

SUMMARY

An investigation was carried out to find out the affect of varietal variation and mineral nutrition on the oil content, quality parameters and fatty acid composition of coconut oil. Mature nuts were collected from 44 well defined varieties/cultivars including hybrids of coconut from the RARS, Pilicode and from the Instructional farm, Vellayani. In addition to this mature nuts were also taken from an ongoing 3^3 confounded factorial experiment with 27 treatments and 2 replications from the CRS, Balaramapuram.

The important findings from the above studies are summarised below.

1. The effect of varietal variation on the oil content was found to be significant. The tall varieties were found to be better oil yielders followed by hybrids and dwarf varieties.

2. The effect of varietal variation on quality parameters like acid value, saponification value and iodine value was found to be significant.

3. The minor quality parameters like Reichert-Meissel value and Polenske value also showed considerable differences due to varietal variation though not statistically tested.

4. The fatty acid profile of the oil from selected varieties also showed considerable variation due to varietal differences.

5. The main effect of K had a significant but negative effect on the oil content of the samples collected. The oil content (in percentage) was not influenced by the variation in N,P and K fertilizers.

6. The influence of N,P and K fertilizers on quality parameters like acid values, saponification value and iodine value was not significant in general. But a negative significant effect was found in the case of P nutrition with respect to saponification value.

7. The minor quality parameters like Reichert-Meissel and Polenske value showed variation due to fertilizer treatments.

8. The random samples taken from the fertilizer experiment showed variation in the fatty acid composition.

On the basis of the present study, it can be concluded that there is significant effect for varietal variation on oil content and quality parameters. In general, tall varieties were found to be better oil yielders followed by hybrids and dwarfs. The variation in the quality parameters may be attributed to variations in the genetic characteristics of the cultivar. The results of the NPK experiment indicate that the effect of mineral nutrition on the quality and fatty acid composition of coconut oil is minor. The indirect effect of fertilizers appears to be more important than the interaction effects.

Findings of the present study pinpoints the following aspects for future investigation.

1. To study the variation in the quality parameters of coconut oil due to seasonal effects.

2. To study the variation in the quality parameters of coconut oil at different stages of maturity.

3. To study the changes in quality parameters occurring during storage and post harvest handling.

4. Fatty acid fractionation should be done for

selected varieties with more number of replications and at different times of harvest.

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APPENDIX - 1

Abstract of anova table of oil content of varieties

Source	D.F	M.S.S.	F
Treatments	23	32.49932	2.569963*
Error	24	12.64583	

* Significant at 5% level.

APPENDIX - 2

Abstract of anova table of acid value of varieties

Source	D.F	M.S.S.	F
Treatments	23	3.670757	2.554693*
Error	24	1.436868	

* Significant at 5% level.

APPENDIX - 3

Abstract of anova table of saponification value of varieties

Source	D.F	M.S.S.	F
Treatments	23	293.7826	4.847565**
Error	24	60.60417	

** Significant at 5% and 1% level.

APPENDIX - 4

Abstract of anova table of iodine value of varieties

Source	D.F	M.S.S.	F
Treatments	23	8.569611	3.327805**
Error	24	2.575155	

** Significant at both 5% and 1% level.

APPENDIX - 5

Abstract of anova table of oil content of nuts from NPK experiment

Source	D.F	M.S.S.	F
Blocks	5	12.1625	1.615243 NS
N	2	5.851563	0.7771176 NS
P	2	9.851562	1.308338 NS
K	2	58.29688	7.742124**
NP	4	39.40625	5.233352**
NK	4	15.85156	2.105169 NS
PK	4	23.85156	3.16761*
NPK	2	72.07031	9.571307**
NP_2K	2	39.40625	5.233352*
NPK_2	2	4.589844	0.6095548 NS
N_2K_2	2	37.33203	4.957886*
Error	22	7.52983	

** Significant at 5% and 1% level.

* Significant at 5% level

NS - Not significant

APPENDIX - 6

Abstract of anova table of acid value of nuts from NPK experiment

Source	D.F	M.S.S.	F
Blocks	5	.2048447	.2639087[NS]
N	2	.8499412	1.09501[NS]
P	2	1.614323	2.07979[NS]
K	2	1.360539	1.75283[NS]
NP	4	1.150412	1.482117[NS]
NK	4	.5886726	.758408[NS]
PK	4	1.712192	2.205878[NS]
NPK	2	.7433643	.9577029[NS]
NP_2K	2	.4413185	.5685665[NS]
NPK_2	2	.4322329	.5568611[NS]
N_2K_2	2	1.664895	2.144944[NS]
Error	22	.7761952	

NS - Not significant

APPENDIX - 7

Abstract of anova table of saponification value of nuts from NPK experiment

Source	D.F	M.S.S.	F
Blocks	5	147.55	1.930192^{NS}
N	2	16.75	.219117^{NS}
P	2	368.125	4.815668*
K	2	90	1.177345^{NS}
NP	4	59.9375	.7840791^{NS}
NK	4	154.75	2.024379^{NS}
PK	4	19.5	.2550914^{NS}
NPK	2	69.875	.9140776^{NS}
NP_2K	2	355.25	4.647243*
NPK_2	2	65.1875	.8527575^{NS}
N_2K_2	2	43.5625	.5698677^{NS}
Eror	22	76.44318	

* Significant at 5% level

NS - Not significant

APPENDIX - 8

Abstract of anova table of iodine value of nuts from NPK experiment

Source	D.F	M.S.S.	F
Blocks	5	5.944434	1.279595 NS
N	2	15.12744	3.256324 NS
P	2	2.155396	.4639692 NS
K	2	1.036133	.2230373 NS
NP	4	2.48114	.5340888 NS
NK	4	2.237793	.481706 NS
PK	4	15.47998	3.332211 *
NPK	2	.772583	.1663058 NS
NP_2K	2	2.008789	.4324107 NS
NPK_2	2	.1216431	2.618482 E-02 NS
N_2K_2	2	1.349854	.2905687 NS
Eror	22	4.645558	

* Significant at 5% level

NS - Not significant

ABSTRACT

Coconut is a perennial oil seed crop with a large number of cultivars having widely varying growth and yield characteristics. It is both an agricultural and industrial crop with immense economic importance. A variety of edible oils are available in the market today with wide variations in quality parameters and nutritional characteristics. Although product quality is influenced by many factors associated with production, harvesting, curing and processing; quality is influenced to a greater extent by the genetic parameters and chemical composition. Assessment of quality parameters and fixing standards for the nutritional aspects are to be considered with top priority for the development of new varieties/cultivars along with the yield attributes. Considering the afore mentioned facts in view, it was felt essential to study the effect of varietal variation and mineral nutrition on the oil content, quality and fatty acid composition of coconut oil.

Nuts collected from different varieties/cultivars from RARS, Pilicode, Instructional farm, Vellayani and palms of an ongoing fertilizer trial of the CRS, Balaramapuram, were subjected to chemical analysis to study the above aspects. The results of the analysis were summarised and appropriate conclusions drawn.

The effect of varietal variation on the oil content and quality parameters like acid value, saponification value and iodine value were found to be significant. Minor quality parameters like Reichert-Meissel and Polenske value also showed considerable differences among the varieties. The fatty acid composition of oil from selected varieties also had shown considerable variation.

The effect of mineral nutrition on the oil quality and fatty acid composition of coconut oil were found to be insignificant. The oil content was not influenced by nitrogen and phosphorous while potassium had a significant but negative effect on oil content. The influence of N, P and K fertilizers on the quality parameters like acid value, saponification value and iodine value was not significant in general. Minor quality parameters like Reichert-Meissel and Polenske value showed variation due to fertilizer treatments. The fatty acid composition of oil from selected treatments were also influenced by mineral nutrition.

From the results of the study it can be concluded that quality parameters of coconut are much influenced by varietal differences than by mineral nutrition. Thus it is evident from the study that the genetic variability has got a greater role to play in modifying quality parameters and chemical composition of the most important tropical edible oil namely coconut oil. Selection and breeding should be directed towards tailoring new varieties with higher oil content, quality indices and fatty acid composition.