STANDARDIZATION OF POSTHARVEST PROCESSING OF GINGER (*Zingiber officinale* Roscoe)

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Standardization of post harvest processing of Ginger (*Zingiber officinale* Roscoe.) " 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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Certified that this thesis, entitled "**Standardization of post harvest processing of Ginger (Zingiber officinale Roscoe)**" is a record of research work done independently by **Sri.K. Ajith Kumar** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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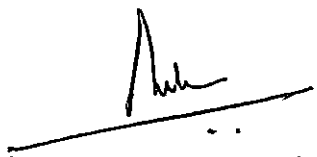

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INTRODUCTION

INTRODUCTION

Ginger is the most important spice obtained from the rhizome of the plant Zingiber officinale Roscoe of the Zingiberaceae family. It is a herbaceous perennial but commercially cultivated as an annual crop.

Ginger is mainly used as a spice in cookery, as a flavouring agent in a wide variety of foods. Its use in the form of preserves and confectionaries such as candy, jelly, ginger toffees and ginger biscuits can not be ignored. It is also used for spicing ginger wine, a cordial beneficial in cold weather. It is an important ingredient in ginger beer which is a good stimulating drink, a carminative and an aromatic to the gastro-intestinal tract. In India, fresh ginger is pickled and used.

India is the largest producer and exporter of dry ginger which accounts nearly 60 per cent of the world production. In India, Kerala produces nearly 50 per cent of the total produce of the country (Bisen and Barholia, 1989).

The Market Research Corporation of India and other agencies like Spices Export Promotion Council points out that

a declining trend is noticed in our ginger export trade. They points out various possible reasons for the sharp decline in our export. The important points are Indian ginger is reported to contain more fibre than ginger from certain other producing countries like Jamaica and Sierra Leone. The price of Indian ginger is also reported to be on the high side by about 20-30 per cent when compared to the ginger marketed by other countries. The adulteration of the materials with affected materials or inferior materials, non-adherence of the quality standards prescribed, are some of the other points reported by them. Non-diversification of our products according to the consumers preference is another important reason for the decline of our export trade.

The two traditional dry ginger products exported from India are the scraped dry ginger and bleached/coated dry ginger whereas the traditional dry ginger product from Nigeria is whole/split (unpealed); Jamica - clean, pealed; Australia - sliced, coated; and Sierra Leone, it is coated/roughly scraped.

In the case of these traditional products from India no effort is seen made to improve the quality and appearance to catch better export as done in case of pepper. Further, not

much work has been done to standardize newer products or to introduce the methods adopted in other ginger exporting countries.

So in the present study emphasis is given to diversify the products by adopting methods like scraping, blanching, boiling, slicing, splitting and coating as done in other countries or in other crops like turmeric, tapioca etc. so as to see whether these methods have any effect on quality and storage life. If any method is identified as better than the traditional methods such can be standardised for use at farmers level. So the present investigation was carried out to study the effect of various methods like scraping, slicing, blanching, boiling and coating and their combinations on the yield and quality of dry ginger and to study the effect of the various methods of processing on storage life and pest and disease incidence.

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

Quality aspects of gingers

The oleoresin from ginger is obtained conventionally by extracting unpealed, powered, dried ginger with volatile solevents, usually acetone, which is later removed in vacuo at low temperature (Goldmann, 1949).

Guenther (1952) reported that to obtain volatile and non-volatile constituents of ginger, ground ginger is percolated with volatile solvents like acetone, alcohol or ether. Subsequent concentration of the solution and careful removal of the solvent in vacuo yields the so called oleoresin of ginger, in which full pungency of the spice is preserved. The qualitative composition of the oleoresin depends upon the solvent used. Oleoresin of ginger (commercially known also as 'gingerin') generally contains, gingerol and zingerone, shogaol, volatile oil of ginger and unidentified resins.

Ginger after liming but before the final drying, when treated with sulphur dioxide (produced by burning sulphur in specially constructed room) produced a white product (Anon, 1953; Sundaram, 1960).

Nigam et al. (1964) reported that yield of oil in the case of ginger ranges between 1.5 and 3.0 per cent. The main constituents of ginger oil are sesquiterpenes like zingiberene, curcumene, tarnesene, sesquiterpene alcohol, zingiberol and non-terpene components like citral, linalool, borneol and geraniol.

The difference in aroma, flavour, pungency and yield of different ginger oleoresins were attributed to many factors (Connell, 1969) such as type of cultivar, harvesting age, choice of solvents and method of extraction.

Connell and Sutherland (1969) further showed that the major pungent constituents of ginger are a mixture of 0 - methoxy phenyl alkanones, the gingerols, with varying lengths of side chains and shogaols the related dehydration product. Based on the aldehyde released from the side chain or alkaline degradation, they proposed naming them (6) -. (8) -, and (10) - gingerols. The three gingerols were found in the ratio of 56:13:31.

Since then, Connell (1970) reported that in an oleoresin prepared under mild conditions, the gingerols constitute about one-third of the total oleoresins. A high content of volatile oil is necessary in ginger for obtaining good quality oleoresin.

According to Natarajan et al. (1970) Kerala ginger is considered to be one of the best in the country, due to its low fibre content, boldness and characteristic aroma and pungency.

Lewis et al. (1972) after a comprehensive study on the efficacy of four solvents (acetone, alcohol, hexane and ethylene dichloride) recommended ethylene dichloride as the most useful solvent.

The presence of high curcumene and low zingiberene contents in fresh ginger as compared to dry ginger was reported by Mathew et al, (1973). Production of the dry ginger of commerce is confined exclusively to the state of Kerala and is mainly of two types, they are Cochin type and Calicut type (Anon, 1976). Natarajan and Lewis (1980) reported that usually the oleoresin content of ginger rhizomes varied from 4 to 6 per cent.

According to Purseglove et al. (1981) crude fibre content of unpeeled ginger may be as high as 10 per cent (on a dry-weight basis), but in commercial dried ginger it is usually in the range of 1.5 - 6 percent. The volatile oil content of commercial dried ginger has been reported to vary between 0.5 - 4.4 per cent.

Akhila and Tewari (1984) reported that the yield of oil varies from 1.5 to 3.0 per cent, depending upon factors such as ginger cultivar, stage of maturity at harvest, the method of preparation and drying, its age and to some extent upon the distillation method.

Histochemical studies of ginger rhizomes were conducted by Mangalakumari et al. (1984). The studies revealed that essential oil cells were seen distributed both in cortex and pith. Gingerol cells exhibited a similar distribution but were independent of essential oil cells. While starch grains were absent in tender stages it was found in the mature stages, mostly distributed in the pith and to a lesser extent in inner cortex. Polyphenols were found in vascular bundles and in meristematic vegetative buds of rhizomes.

Chen et al. (1986b) reported that pungent principles of ginger were extracted with liquid carbon dioxide (600-700 psi). Gopalam and Ratnambal (1989) reported that ginger oil obtained by hydro or steam distillation of coarsely ground ginger rhizome is valued for flavour and perfumery. The yield of oil vary from 1.4 per cent to 2.6 per cent on dry weight basis.

Mathai (1974) found that oleoresin content was high during the early stages of growth which decreased from 10.1 per cent during the third month to 4 - 8 per cent during seventh month.

Muralidharan (1974) reported that a high percentage of oleoresin (7.1 per cent) was observed in the variety Kuruppampady. Since the varieties Kuruppampady, Wynad Local, Assam and Valluvanad, possessed both the qualities of high yield and high content of oleoresin they are suitable for large scale cultivation to feed the processing industry.

According to Mathai (1975) oleoresin content decreased with maturity. Nybe and Nair (1978) reported that the variety Kuruppampady have a dry ginger recovery, oleoresin and crude fibre percentage of 23.00, 8.00, 6.47 respectively. They further observed that oleoresin and oil contents were highly significant among the different periods of maturity. The percentage of oleoresin and ginger oil were maximum at 165 days after planting.

Subsequent investigations by Nybe et al. (1980) revealed that a significant variation in oleoresin content was seen in 25 ginger cultivars, the maximum (10.8 per cent)

when it attains proper maturity is cleaned of all the roots and washed free of mud and is soaked in water overnight, which facilitates peeling. The following morning, the rhizomes are rubbed between hands and are cleaned thoroughly. The outer skin is scraped of by means of a sharpened bamboo piece and the peeled product is washed in water and cleaned well. It is thinly spread over evenly under the sun and is dried for about 5-7 days to 10 per cent moisture level. At the time of drying, the lots are turned frequently to ensure uniform drying. After drying, the rhizomes are again rubbed well between hands in order to remove any outer skin still adhering. The dry ginger thus prepared is known as rough or unbelached ginger. Instead of relying on favourable seasonal conditions for sundrying the ginger, the use of mechanical rotary drier is preferred (Narayanan et al. 1978). Experiments have proved that peeling of ginger could be rendered easier by dipping in boiling lye followed by washing and then steeping in 4 per cent acid for two hours (Anon 1962).

Bleached or coated ginger

Kannan and Nair (1965) recommended that in order to prepare white ginger of superior quality, the cleaned and peeled raw rhizomes have to be soaked in water and 2 per cent lime water for 6 hours before drying.

The peeled ginger is soaked in thick lime water for some time, then it is fumigated with sulphur fumes for 12 hours and dried in the sun for a day. This is repeated once or twice to obtain a fully bleached white produce which is then thoroughly dried and stored. Chlorides of lime, sulphurous and alkali sulphates are used for bleaching. Coating with chalk or dipping in lime water is practiced not merely to improve the appearance but also to ward off attacks of insects such as stone weevil (spice weevil Stegobium panicum) which, if unchecked, soon reduced the rhizome to unsightly powder (Narayanan et al., 1978).

Bleached ginger is also prepared by dipping the unbleached dry ginger in fresh slaked lime solutions and then sun drying. This process is repeated several times to get a white coloured ginger (Natarajan and Lewis, 1980).

Improvement over traditional products and product development

Traditionally we have produced only two types of dry ginger ie, dry unbleached ginger and bleached/coated ginger. Recently attempts have been made for diversification of our products according to consumers preference. The available literature on product diversification in ginger are reviewed below.

Damayanthi et al. (1980) reported a new method for extracting oleoresin from green ginger. The ground paste is percolated with cold hexane for three times. The extracts were drained at 8 hour intervals. The water layer was discarded from the combined extracts and the hexane layer was concentrated to get the oleoresin. The last traces of hexane were removed as an azeotrope with acetone, using ejector vacuum. Hexane gave a satisfactory product in 0.5 to 0.6 per cent yields.

Natarajan and Lewis (1980) reported that ginger powder is made by pulverising the dry dinger to a mesh size of 50-60.

They also reported that the oleoresin is obtained by extraction of powdered ginger with solvents like acetone, alcohol or ethylene-di-chloride. The level of residual solvents in the finished product should be less than 30 ppm.

Ginger oil is obtained by steam distillation of the dry ginger powder. The oil is devoid of the pungent taste (bite) of the spice. The oil is light yellow in colour, soluble in ether, sparingly soluble in alcohol and insoluble in water (Natarajan and Lewis, 1980; Shankaranarayana et al. 1988).

Narayanan (1988) reported that during the preparation of ginger powder, some fraction of aroma is lost due to the heat generated during the process of grinding. To avoid this cryo-grinding is practiced in some western countries where the spice is pre-cooled in liquid nitrogen and then grinded thus retaining the total aroma of the spice.

Shankaranarayana et al. (1988) reported that for the production of unbleached type ginger, the outer skin is peeled off using split bamboo knife. Care should be taken to remove only the thin outer skin without damaging the essential oil cell, so as to avoid any loss of oil during drying. Peeling can also be done efficiently by putting the rhizomes in rotating wire mesh drums. After peeling, the material is dried in the sun to a moisture level of 10-12 per cent. Generally, this takes 20-25 days under good sunshine. Sometimes, the rhizomes are sliced and dried using mechanical driers, in order to achive quicker drying. This product is suitable for preparation of ginger powder or oleoresin.

Shankaranarayana et al. (1988) also reported that bleached ginger is produced by soaking the peeled rhizomes in 2 percent lime water for about 6 hours, followed by sun drying. This process is repeated for four to five times to get a white coloured dry ginger. They further reported that

ginger powder is made by cryogenic/multistage grinding to a mesh size of 50-60. For maintaining a correct balance between pungency and aroma, the oleoresin is often blended with the volatile oil.

The procedure for the production of 'sonth', a type of dry ginger has been outlined by Bisen and Barholia (1989). The rhizomes are kept in broad, open metal drums. They are then filled with water above the level of rhizomes and water is drained out after 24 hours. Then peeling is done with the help of bamboo sticks. The peeled rhizomes are soaked in 2 per cent lime water. Then the dried material is exposed to sulphur fumes for 12 hours and again dried in the sun for a day. The process may be repeated till bleaching is satisfactory. Afterwards this is dried in the sun for a week or more till it becomes hard. The dried product is called 'sonth'.

Spray drying is the most commonly used encapsulation method for ginger (Raghavan et al; 1990). The technique involves three basic steps viz; preparation of the dispersion or emulsion, homogenisation of the dispersion and atomisation of the mass into the drying chamber. They also found that the moisture pick up was negligible over a period of 2 years storage. The loss of flavour, over a 2 year period of storage, ranged from 4 to 9 per cent.

Different methods of processing followed in other ginger producing countries

Purseglove *et al*. (1981) after reviewing the work carried out on various ginger products in leading exporting countries have listed the following dry products of ginger.

Jamaican dried ginger

Clean, peeled dry ginger in whole form, light buff in colour, 6-9 cm long and irregular in shape. The volatile oil content ranges from 1 to 1.3 per cent and the non-volatile ether extract is about 4.4 per cent.

Nigerian dried ginger

This is processed in the whole as well as split form. The splits being coated and cut open, are in terms of appearance, of an even low quality and value. The non-volatile ether extract content is of about 6.5 per cent and the volatile oil content is in the range of 2-2.5 per cent.

Sierra Leone dried ginger

This is prepared from whole rhizomes which are either

coated or only rough scraped. This is very pungent with a non-volatile ether extract content of about 7 per cent and it has a good volatile oil content of about 1.6 per cent.

Australian dried ginger

The bulk production of this type is of the artificially dried slices of coated rhizomes. Dried ginger from the "mid-crop" possesses the greatest pungency and volatile oil content up to 4.4 per cent.

Chinese dried ginger

This is prepared by whole, peeled form and as coated slices. It is often bleached with sulphur dioxide.

Methods followed in the processing of Turmeric and Tapioca

Turmeric

Krishnamurthy et al. (1975) observed that there was no appreciable change in the volatile oil or colour content of turmeric obtained by different processing techniques. Also, boiling or slicing, reduced the drying time considerably.

Sampathu et al. (1988) found that dried turmeric obtained under farm-processing conditions by different treatments viz; cooking and traditional processing, were similar in quality with respect to drying characteristics, appearance, colour and oleoresin contents. Cooking and/or slicing helped to drastically reduce the drying period.

Tapioca

Pillai and Sreemoolanathan (1970) have proved that chips of 10 to 15 mm thickness could be satisfactorily dried in 3 to 4 days exposing the chips to the sun for 8 hours a day. The thickness of the slices are reported to have an effect on drying period.

Dried cassava chips have long shelf life quality. The shelf life qualities can be influenced by the methods of processing and the ways in which the dried chips are stored (Coursey et al. 1972).

Thampan (1979) reported that in tapioca immediately after the harvest, the tubers are peeled, sliced and dried in the sun for 4 to 5 days to produce the white chips. Parboiled chips, produced by freshly harvested tubers, are

sliced without peeling and cooked in boiling water for about 10 minutes prior to drying. The white chips keep well for about 6 months but parboiled chips can be stored for 12 months or more.

Quality changes due to various processing methods and storage

Elsdon and Mayne (1937) reported that the extent of peeling might influence the pungency levels, since the pungent constituents are mainly located in the outer layers of ginger rhizomes.

Australian dried ginger is prepared by artificial drying of the rhizomes (Richardson, 1966). Peeling of whole rhizomes is carried out by machine while rhizomes intended for the production of coated sliced ginger are cut into slices 1/8 inch (3.175 mm) thick. The optimum temperature for artificial drying of sliced ginger for the spice market should be less than 57°C, but for extraction purpose, 81°C will be satisfactory.

Connell (1969) showed that excessive heating during the removal of solvent can cause the gingerols to be degraded to the less pungent shogaols or to the weakly pungent zingerone

and aliphatic aldehyde, with loss of pungency and the development of off-flavours. He also reported that poor handling during preparation, storage, and utilisation of dried ginger and its oleoresin causes considerable deterioration of quality.He also showed that decrease of gingerols and increase of shogalos, both due to drying conditions and storage of oleoresin.

Connell and Jordan (1971) reported that oil with green ginger oil odour can also be obtained from dry ginger, if the drying is carried out in a controlled condition. For this, green ginger is to be sliced and dried in a cross-flow drier at 60^{o}C before distillation.

Krishnamurthy et al. (1972) reported that the disadvantages of the use of spice powder are quality variations from batch to batch caused by uneven distribution of flavour, variations in product appearance, loss of flavour strength during storage, and insect infection. These problems can be greatly minimised by using the extractives like essential oils and oleoresins.

Natarajan et al. (1972) reported that peeling for 60 seconds in the Hobart abrasive peeler was conducive for the production of a high-grade ginger with satisfactory drying

characteristics. But hand-peeling was found to be superior to mechanical peeling which yields a dried product uniform in appearance, size and colour.

Mathew et al. (1973) have noted that up to 20 per cent of the volatile oil can be lost during the sundrying and that the lemon-like aroma becomes weaker in the process. The major oil loss to be expected during the drying of ginger is of the low boiling components, which include the citrals.

Ananthakrishna and Govindarajan (1974) reported that gingerol is the primary pungent principle of ginger oleoresin and that shogaol is progressively formed by poor handling during drying and on storage. Prolonged storage appears to degrade both gingerol and shogaol.

Salzer (1975) indicated the presence of arcurcumene in fresh ginger oil which is formed on storage due to conversion of zingiberene and β -sesquiphellandrene, the main flavour components of freshly prepared oil.

Narasimhan and Govindarajan (1978) reported that the pungent compounds of ginger are homologous gingerols, the dehydrated product, shogaols and the dehydration product,

zingerone. The changes in these compounds are reported to affect quality with reduction in pungency and formation of off-flavour.

Purseglove et al. (1981) after reviewing the works carried out on ginger products have reported that during the drying stage, ginger rhizomes lose about 60-70 per cent of their weight and achieve a moisture content of 7-12 per cent and traditional drying methods can result in the loss of some volatile oil (upto 20%) by evaporation and in the destruction of some of the heat sensitive pungent constituents. Pungency reduction is usually less with split (or sliced) than with whole rhizomes. Artificial drying, when carried out under carefully controlled conditions minimizes the loss of volatile oil and pungency. They further reported that shogaol formation can even occur during the drying of ginger rhizome and it is more extensive with whole, dried ginger than with sliced dried ginger. This is attributed to the longer drying time required for whole ginger. The shogaols are found to be susceptible to acid p^H and heat treatment and they probably transform to non-pungent polymers. Thus, the pungency of oleoresins decreases steadily on storage as the gingerols are first transformed to shogaols, which are in turn degraded.

Mc Hale *et al* (1989) reported that gingerols, the pungent principles from ginger, are thermally liable. Two degradation pathways have been established; retro-aldol condensation to zingerone and the appropriate aldehyde, and dehydration to shogaols. The shogaols are also sensitive to certain processing conditions. A series of gingerols ethylated at the aliphatic hydroxyl group has been detected in extracts of ginger. Ethanol is commonly used to extract the pungent principles from the rhizomes.

Gopalakrishnan and Narayanan (1990) reported that the ginger extract obtained by carbon dioxide extraction possessed a natural flavour and better colour. The carbon dioxide extract of ginger was more sweet, aromatic, spicy and pungent with less harsh, terpeny, earthy and woody notes compared to the product obtained from same variety by the conventional distillation method.

Duration of storage, pest and diseases

Richardson (1967) carried out controlled storage tests on whole sliced ginger and ground ginger, packed in several forms of multi-wall paper bags. He estimated the contents of volatile oil and oleoresin for all samples at monthly

intervals for a period of five months. The results indicated that there was no significant change in oleoresin content in either the sliced or ground product. Packages of sliced ginger were found to have retained their full oleoresin and volatile oil contents, but the oil contents of all samples of ground ginger decreased by about 50 per cent.

Storage pests

Yoshio and Takaakira (1985) reported that stored rhizomes of ginger Zingiber miaga Roscoe, are attacked by the larvae of two sciarid pests, Psilosciara flammulinae and Phytosciara zingiberis. About 16 per cent of total rhizomes stored was infested.

Jacob (1986) reported that the storage pests of ginger and turmeric are coffee bean weevil - Araecerus fasiculatus, drug store beetle - Stegobium paniceum, cigarette beetle - Lasioderma serricorne and two storage moths - Pyralis manihotalis and Setomorpha rutella. The coffee bean weevil and the storage moth attack both fresh and dry ginger while the drug store beetle and cigarette beetle deteriorate dry ginger.

A new pest, book lace - Granthakita cuttackae was identified during this study. This was identified by the Zoological Survey of India, Calcutta on 2nd November 1990.

Diseases

Sharma and Jain (1977) revealed that the rhizomes were infested during storage by Fusarium oxysporam, Pythium deliense, P. myriotvlum, and Psendopapulaspora kendrickii. The fungi present in the dark region definitely deteriorate the quality of ginger.

MATERIALS AND METHODS

3 MATERIALS AND METHODS

3.1 Experimental materials

The investigation in the thesis were carried out after collecting 100 kg fresh ginger (variety Kuruppampady) from Kuruppampady near Perumbavur.

After collecting fresh ginger initial evaluation of qualities like moisture, essential oil, oleoresin were carried out.

For each types of processing one kilogram ginger had been taken and following processing were done as per the treatments. They were:-

T1 Unpealed and drying

T2 Splitting and Drying

T3 Scraping and drying

T4 Slicing and drying

T5 Blanching and drying

T6 Boiling and drying

T7 Coating and drying

T8 Splitting, scraping and drying

T9 Splitting, blanching and drying

T10 Splitting, boiling and drying

T11 Splitting, coating and drying

T12 scraping, splitting and drying

T13 scraping,slicing and drying

T14 scraping, blanching and drying

T15 scraping, boiling and drying

T16 scraping, coating and drying

T17 slicing, blanching and drying

T18 slicing, boiling and drying

T19 slicing, coating and drying

T20 Blanching, coating and drying

T21 Boiling, coating and drying

T22 Splitting, boiling, coating and drying

T23 Scraping, slicing, blanching, and drying

T24 Scraping, boiling, coating and drying

T25 slicing, boiling,coating and drying

The processing methods for the preparation of various treatments are described below:

1. Unpealed and drying

One kilogram of fresh ginger was sun dried without any processing.

2. Splitting and drying

In this method unpealed rhizomes were split longitudinally and then sundried.

3. Scraping and drying

The skin of the whole rhizomes were removed by scraping and then sundried.

4. Slicing and drying

Unpealed rhizomes were sliced to a size of 4mm thickness and sundried.

5. Blanching and drying

This is done by dipping the whole rhizomes in boiling water for one minute before sundrying.

6. Boiling and drying

The ginger rhizomes were cooked in the boiling water. The whole mass was boiled till the fingers become soft which was tested by piercing a wooden needle. The end point was

noted where needle passed through the finger without much resistance. The cooked fingers were taken out and sundried.

7. Coating and drying.

Unpealed, whole rhizomes were dipped in 2 per cent lime water for 6 hours before sundrying.

8. Splitting, scraping and drying

The whole rhizomes were split longitudinally followed by scraping and then sundrying.

9. Splitting, blanching and drying

The unpealed rhizomes which were split longitudinally were dipped in boiling water for one minute and sundried.

10.Splitting, boiling and drying

This was done by splitting rhizomes longitudinally, followed by boiling till the fingers become soft and then sundried.

11. Splitting, coating and drying

The whole rhizomes which split longitudinally were dipped in 2 percent lime water for 6 hours and sundried.

12. Scraping, splitting and drying

This was done by scraping the skin of whole rhizomes without damaging the underlying tissue followed by longitudinal splitting and sundried.

13. Scraping, slicing and drying

In this method scraping of the rhizomes was followed by slicing and sundrying.

14. Scraping, blanching and drying

After removing the skin by scraping rhizomes were dipped in the boiling water for one minute and sundried.

15. Scraping, boiling and drying

After removing the outer skin, the whole rhizomes were boiled till the fingers become soft and sundried.

16. Scraping, coating and drying

In this method after removing the outer skin, the fingers were dipped in 2 per cent lime water for 6 hours and sundried.

17. Slicing, blanching and drying

In this method slicing of rhizomes for about 4mm thickness was followed by diping in boiling water for one minute and sundrying.

18. Slicing, boiling and drying

In this method whole rhizomes were sliced (about 4 mm thickness) followed by cooking till the fingers become soft and then sundried.

19. Slicing, coating and drying

Sliced rhizomes of about 4 mm thickness were dipped in 2 per cent lime water for 6 hours and then sundried.

20. Blanching, coating and drying

In this method whole rhizomes were dipped in boiling water for one minute followed by dipping in 2 percent lime water for 6 hours and then sundried.

21. Boiling, coating and drying

In this method whole rhizomes were boiled till the fingers become soft followed by dipping in 2 per cent lime water for 6 hours and then sundried.

22. Splitting, boiling, coating and drying

In this method whole rhizomes were split longitudinally and boiled till they became soft followed by dipping in 2 per cent lime water for 6 hours and then sundried.

23. Scraping, slicing, blanching and drying

The skin of the rhizomes were scraped and sliced to about 4 mm thickness and dipped in the boiling water for one minute and then sundried.

24. **Scraping, boiling, coating and drying**

The whole rhizomes scraped and boiled till it became soft and dipped in 2 per cent lime water for 6 hours followed by sundrying.

25. **Slicing, boiling, coating and drying**

The whole rhizomes were sliced to about 4 mm thickness and cooked in the boiling water till they became soft, dipped in 2 per cent lime water for 6 hours and sundried.

All processed samples were sundried to a moisture level of 10 percent by repeated moisture estimation. The dried material was stored in the polythene lined gunny bags for one year. During these periods following observations were noted:

1. Weight loss due to preparation of end product (Once immediately after processing).

2. Moisture (Percentage)

3. Essential oil (Percentage)

4. Oleoresin (Percentage)

5. Crude fibre (Percentage)

6. Weight loss due to storage

7. Attack of pests/disease if any

8. External /internal colour difference if any.

3.2. Statistical method

The design of the experiment was CRD with 25 treatments with 4 replications. One replication was kept for biometrical observations like weight loss due to storage, attack of pest/diseases and external/internal colour difference if any.

3.3 Analytical technique

3.3.1 Estimation of moisture content

The samples were powdered to a mesh size of 60 using a grinder and homogenously mixed for analysis. Moisture of the samples were determined by toluene distillation method using Dean and Stork apparatus (AOAC, 1975).

Three gram of ground sample was taken in a round bottom flask and 100 ml toluene was added to it. The flask was then attached to Dean and Stork apparatus with a reflux condenser. Heated the flask using a heating-mantle. When water started boiling, the vapours along with toluene rose up the condenser, got condensed and along with moisture settled in such a way that moisture settled below the toluene layer. Distillation was continued till the volume of water collected in the apparatus remained constant. The apparatus was subsequently cooled and the volume of water collected was directly read from the graduated scale of the apparatus. The moisture content of the samples were calculated using the formula

Moisture (percentage) = V/W x 100

where V= Volume of water collected in millliliteres

W= Weight of samples (ginger) taken in gram.

3.3.2. Estimation of Essential Oil (Volatile oil)

The essential oil in the samples were estimated by Clevenger distillation method (Clevenger,1928). The

distillation was carried out using a Clevenger apparatus with a trap for oils lighter than water. The apparatus consisted of a round bottom short necked flask, a trap for collecting oil and a condenser of cold-finger type.

Twenty gram of dried powdered samples were taken in the round bottom flask. About 500 ml water was added and the Clevenger apparatus was attached to the flask. The mixture was heated using a heating-mantle. The volatile oil along with steam condensed and oil together with collected in the trap as separate layers. The water in the trap was drained at periodic intervals.

The distillation was continued for 4-6 hours until further recovery of oil was not seen. The volume of oil collected was directly read from the trap.

Essential oil content of the material was calculated using the formula

Essential oil (Percentage) = V/W x 100

where, V= volume of oil collected in millileters

W= weight of sample taken in gram.

3.3.3.Estimation of Oleoresin

The oleoresin of ginger was estimated using a soxhlet apparatus (A.O.A.C.1975). Five gramme of ground material was accurately weighed and placed in a dried extraction thimble. An empty flat bottomed flask was weighed and soxhlet extractor connected to it. The thimble was then introduced in to the extractor containing the sample.

A condenser was also attached to the extractor. Sufficient quantity of acetone was poured through the condenser mount so as to cause a siphoning of acetone to the flask. A further quantity of acetone was poured so that its level in the extractor remained just below the syphon level. The flask was kept in a warm water bath at 55-60^{o} C. Cold water was circulated through the condenser continuously during the extraction period.

On heating, the solvent acetone vapourised and got condensed inside the condensor till the collected acetone again siphoned off to the flask. Likewise repeated extractions were carried out until ten siphoning of acetone were over. The condensor was later removed and the extractor was disconnected from the flask.

Excess acetone in the flask was evaporated off by drying the flask in an oven at 100° C for 10 minutes. The flask was then cooled and weighed. The increase in weight of flasks gave the quantity of oleoresin present in the sample and it was expressed in percentage.

3.3.4.Estimation of crudefibre

The samples used for oleoresin estimation were utilised for the determination of crudefibre using the method suggested by AOAC(1975).

After removal of crude fat, 2 gramme of dried sample taken in a 500 ml beaker, 200 ml of 1.25% H_2SO_4 was added and allowed the contents to boil. The level of liquid in the beaker was marked before boiling and the level was maintained by addition of water. Boiled the contents for 30 minutes and filtered it through a musline cloth supported on a funnel, washed the residue with hot water till the acid removed.

Transfered the residue back to the beaker with the help of a spatula and washed the musline cloth into the beaker with 1.25% NaOH solution which was previously boiled so as to transfer the particles adhered to the musline cloth. Then add 1.25% boiling NaOH to the beaker upto 200 ml mark and boiled

for 30 minutes. Filtered the contents through the musline cloth and washed it free of alkali using hot water.

Transfered the residue into a silica basin and washed the last traces of the residue on the musline cloth into the basin with a jet of water. Dried the contents of the basin on a water bath and then in an electric air oven at 105° C. Dried, cooled and weighed to constant weight. This residue was ignited into a muffle furnace at 600° C to white ash and weighed to constant weight. Subtracted the weight of ash from the weight of the residue and dried at 105° C which gave the weight of crudefibre.

Weight of moisture free sample : W

Weight of silica dish +
residue dried at 105° C : a

Weight of silica dish + ash : b

weight of crudefibre : a-b

Percentage of crude fibre : a-b/w x100

3.4 Recording of weight loss due to storage

Each sample of the one replication was weighed at bimomonthly interval and weight loss recorded.

3.5 Identification of pest/disease attack

Attack of pest/disease including book lice was examined at bimonthly intervals. The specimens were sent to Zoological Survey of India, 34, Chithrajan Avenue, Calcutta for identification.

3.6 External/internal colour difference

Each sample was examined for external/internal colour difference at bimonthly intervals.

3.7 Statistical analysis

The data generated from the experiments were subjected to analysis of variance technique. (Panse and Sukhatme 1961).

RESULTS

4 RESULT

The observations recorded from the experiment were statistically analysed and the important findings are presented below

4.1 Quality of ginger prior to processing

One kilogram fresh ginger was taken for each type of processing. Before processing from the whole lot of the green ginger, samples were taken for analysis of moisture content, essential oil content, oleoresin content and crude fibre content. The average values were 68.8%, 3.06%, 5.80% and 6.67%, respectively (Table 1).

4.2 Observations after processing

4.2.1 Drying percentage

The results given in Table 2 revelaed a significant influence of processing methods on weight of end product. The drying percentage ranged from a minimum 25% to a maximum of 36.17%.

Table 1 Quality of ginger prior to processing

Samples	Moisture (%)	Essential oil (%)	Oleoresin (%)	Crude fibre (%)
1	70.00	3.00	5.67	6.75
2	66.00	3.10	5.80	6.50
3	68.00	3.20	5.85	6.70
4	70.00	3.00	5.90	6.66
5	70.00	3.00	5.80	6.75
Mean	68.80	3.06	5.80	6.67

The treatment T_1 recorded a maximum drying percentage of 36.17%. This was statistically on par with treatments T_{21}, (35%) and T_6 (34.50%).

The treament T_{21}, with a drying percentage of 35% was also on par with T_6 (34.50%), T_{22} (34.25%) and T_{20} (33.83%).

The treatment T_{22} with a drying percentage of 34.25% was also on par with T_{20} (33.83%) and T_4 (32.75%).

The treatment T_4 with a drying percentage of 32.75%. was also on par with T_{14} (32.50%), T_2 (32.00%), T_3 (31.67%), T_{10} (31.67%), T_5 (31.67%), T_{19} (31.33%), T_{15} (31.33%) and T_9 (31.17%).

The treatment T_{14} with a drying percentage of 32.50% was also on par with T_2 (32.00%), T_3 (31.67%), T_{10} (31.67%), T_5 (31.67%), T_{19} (31.33%), T_{15} (31.33%), T_9 (31.17%), T_{17} (31.00%), T_{12} (31.00%), T_7(31.00%) and T_{13} (30.83%).

The treatment T_3 with a drying percentage of 31.67% was also on par with T_{10} (31.67%), T_5 (31.67%), T_{19} (31.33%), T_{15} (31.33%), T_9 (31.17%), T_{17}(31.00%), T_{12}(31.00%), T_7 (31.00%), T_{13} (30.33%), T_{11} (30.75%), T_8 (30.75%) and T_{16} (30.33%).

Table 2 Average days taken for drying, weight of samples after processing and percentage recovery of dry ginger

Treatments	Days	Weight	Percentage recovery of dry ginger
1	30	361.67	36.17
2	10	320.00	32.00
3	11	316.67	31.67
4	04	327.50	32.75
5	27	316.67	31.67
6	06	345.00	34.50
7	27	310.00	31.00
8	07	307.50	30.75
9	07	311.67	31.17
10	06	316.67	31.67
11	07	307.50	30.75
12	05	310.00	31.00
13	05	308.33	30.83
14	07	325.00	32.50
15	06	313.33	31.33
16	15	303.33	30.33
17	04	310.00	31.00
18	04	301.67	30.17
19	04	313.33	31.33
20	26	338.33	33.83
21	24	350.00	35.00
22	06	342.50	34.25
23	04	250.00	25.00
24	06	278.33	27.83
25	04	296.67	29.67
F	1.70 **	13.69 **	
SE	0	6.13	
CD	0	17.43	

** Significant at 1 percentlevel

The treatment T_{10} was not only on par with the above treatments but was also on par with T_{18} (30.17%). The treatment T_{19} was also on par with T_{25} (30.17%).

The treatment, T_{24} recorded a drying percentage of 27.83%. The treatment T_{23} recorded the lowest drying percentage of 25%.

In short the recovery of dry ginger due to different treatments revealed that the rhizomes when dried without any treatment gave maximum recovery of 36.17 percent, whereas in the scraped rhizomes, split rhizomes and sliced ones the percentage recovery was reduced.

4.2.2 Number of days taken for drying

The data presented in Table 2 revealed a significant influence of processing methods on drying periods. This period ranged from 4 days to 30 days. In the treatments T_4, T_{17}, T_{18}, T_{19}, T_{23} and T_{25} the number of days taken for drying was only 4 days followed by 5 days in T_{12} and T_{13}. Treatments T_6, T_{10}, T_{15}, T_{22} and T_{24} took 6 days followed by 7 days in treatments T_8, T_9, T_{11} and T_{14}. Treatments T_2, T_3, T_{16}, T_{20} and T_{21} took 10, 11, 15, 24 and 26 days, repectively

for drying. Treatments T_5 and T_7 took 27 days, whereas T_1 took a maximum of 30 days for drying.

In short, whole ginger rhizomes when dried without scraping, splitting and slicing took longer periods for proper drying along with coated rhizomes. When size reduction of rhizomes were attempted by splitting and slicing, it reduced the number of days taken for proper drying drastically. Sliced rhizomes took only 4 days for drying.

4.2.3 Moisture content at different periods of storage (%)

The data given in Table 3 revealed that during the initial periods (I, II and III) all the treatments had 10% moisture content.

During the fourth period there was significant difference among treatments. Treatment T_1 possessed a moisture content of 10% and was on par with all other treatment except T_2 which had a moisture content of 7.8% and was on par with treatments T_3, T_4, T_{14}, T_{22}, T_{23} and T_{25}.

During the fifth period T_1 had a moisture content of 10% which was on par with all other treatments except T_8 which had a moisutre content of 7.8% and was on par with

Table 3 Moisture content at different periods (%)

Treatments	PERIODS (BIMONTHLY) I	II	III	IV	V	VI	Pooled mean
T1	10	10	10	10	10	10	10
T2	10	10	10	7.8	6.7	6.7	7.07
T3	10	10	10	6.7	6.7	6.7	6.7
T4	10	10	10	6.7	6.7	6.7	6.7
T5	10	10	10	10	10	7.8	9.27
T6	10	10	10	10	10	8.9	9.63
T7	10	10	10	10	8.9	6.7	8.53
T8	10	10	10	8.9	7.8	6.7	7.8
T9	10	10	10	10	10	10	10
T10	10	10	10	10	7.8	6.7	8.17
T11	10	10	10	10	10	6.7	8.90
T12	10	10	10	10	10	10	10
T13	10	10	10	10	10	10	10
T14	10	10	10	7.8	6.7	6.7	7.07
T15	10	10	10	10	10	8.9	9.62
T16	10	10	10	10	10	8.9	9.63
T17	10	10	10	8.9	6.7	6.7	7.43
T18	10	10	10	8.9	8.9	8.9	8.90
T19	10	10	10	10	8.9	8.9	9.27
T20	10	10	10	10	10	10	10
T21	10	10	10	10	8.9	8.9	9.27
T22	10	10	10	6.7	6.7	6.7	6.7
T23	10	10	10	7.8	6.7	6.7	7.07
T24	10	10	10	10	10	10	10
T25	10	10	10	6.7	6.7	6.7	6.7
Mean	10	10	10	9.08	8.59	8.06	8.58
F				5.79**	7.47**	6.035**	5.458**
SE	NS	NS	NS	0.539	0.539	0.582	0.554
CD				1.532	1.532	1.654	1.542

F (period) 6.965**

F (period x Treatment) 0.477 NS

** Significant at 1 percent level

NS - Not significant

treatments T_2, T_3, T_4, T_{10}, T_{14}, T_{17}, T_{22}, T_{23} and T_{25}.

During the sixth period the data revealed that there was significant difference among the treatments. Treatment T_1 possessed a moisture content of 10% which was on par with all other treatments except T_5 which having a moisutre content of 7.8%, was on par with T_2, T_3, T_4, T_7, T_8, T_{10}, T_{11}, T_{14}, 17, T_{22}, T_{23} and T_{25}. Here the treatments difference did not reveal any specific trend in moisutre percentage. The moisture content of T_1, T_9, T_{12}, T_{13}, $T_{20}$and T_{24} did not change from the beginning till the end.

Pooled analysis of the data revealed that the interation effect was not significant.

4.2.4 Essential oil content at different periods (%)

The data on essential oil content at different periods were analysed separately and the mean values are presented in Table 4.

The results showed that during the first period the essential oil content ranged from 1.25% to 3%. The treatment T_1 recorded a maximum of 3%. This was followed by T_6 with 2.5 % which was on par with T_4 and T_5. The treatment T_{21} rank third with 2.33%. The treatment T_3 recorded a value of 2.16% followed by T_{14} with a value of 2% which was on par

with T_7, T_{16} and T_{20}. The treatment T_2 recorded a value of 1.77% and was on par with T_{24}, T_{23}, T_{22}, T_{19}, T_{18}, T_{17} and T_{13}, T_{12}, T_{11} and T_{10} with a value of 1.66%.

The results showed that during the second period the essential oil content ranged from 1.25% to 3%. The treatment T_1 recorded maximum 3% followed by 2.5% in T_6, which was on par with T_4 and T_5. The treatment T_{21} ranked third with a value of 2.33%. The treatment T_3 with a value of 2% was on par with T_{14}, T_7, T_{20} and T_{16}. The treatment T_2 with an essential oil content of 1.77% ranked fifth.

The results showed that during the third period the essential oil content ranged from 1% to 3%. The treatment T_1 recorded maximum of 3%. This was followed by 2.33% in treatment T_4. The treatment T_3 ranked third with a value of 2% which was on par with T_5 and T_{20}. The treatment T_{21} recorded a value of 1.77% and was on par with T_2, T_6, T_{14} and T_{16} with an essential oil content of 1.66%.

The results showed during the fourth period the essential oil content ranged from 1% to 2.22%. The treatment T_4 recorded a maximum of 2.22% essential oil. This was followed by T_1 with a value of 2% which was on par with T_5 and T_{20} and these treatments ranked third. The treatment T_{16} recorded a value of 1.66% and was on par with T_3, T_{21},

T_6, T_{18} and T_{14} with a value of 1.55%.

During the fifth period the essential oil content was found to range from 1% to 2%. The treatment T_1 recorded a maximum of 2% and was on par with T_5, T_4 and T_{20} with a value of 2%, respectively. The treatment T_{16} recorded a value of 1.66% which was on par with T_3, T_{21}, T_{18} and T_{14} with a value of 1.55%.

The results showed that during the sixth period, the essential oil content ranged from 0.87% to 2%. The treatment T_4 recorded a maximum of 2% and was on par with T_5 with a value of 1.89%. The treatment T_5 was on par with T_{20}. The treatment T_{20} with a value of 1.66% was on par with treatments T_1 and T_{16}. The treatment T_1 with a value of 1.55% was on par with the treatments T_{16}, T_6, T_2, T_3, T_{18}, T_8, T_7 and T_{14} with a value of 1.33%.

Pooled analysis of the data revealed that the average essential oil content was not consistent over different periods. Significant interactions were observed between periods and treatments. So the average effects of treatment over the periods were tested against the interaction.

Table 4 Percentage of essential oil at different periods

Treatments	PERIODS (BIMONTHLY) I	II	III	IV	V	VI	Pooled mean
T1	3.00	3.00	3.00	2.00	2.00	1.55	2.43
T2	1.77	1.77	1.66	1.33	1.33	1.33	1.53
T3	2.16	2.00	2.00	1.66	1.55	1.33	1.78
T4	2.50	2.50	2.33	2.22	2.00	2.00	2.26
T5	2.50	2.50	2.00	2.00	2.00	1.89	2.15
T6	2.50	2.50	1.66	1.55	1.44	1.33	1.83
T7	2.00	2.00	1.50	1.44	1.44	1.33	1.62
T8	1.50	1.50	1.44	1.44	1.44	1.33	1.44
T9	1.25	1.25	1.00	1.00	1.00	0.87	1.06
T10	1.66	1.66	1.33	1.33	1.33	1.22	1.42
T11	1.66	1.66	1.33	1.33	1.33	1.00	1.39
T12	1.66	1.66	1.33	1.33	1.33	1.00	1.39
T13	1.66	1.66	1.55	1.33	1.33	1.11	1.44
T14	2.00	2.00	1.66	1.55	1.55	1.33	1.68
T15	1.50	1.44	1.33	1.33	1.33	1.11	1.34
T16	2.00	2.00	1.66	1.66	1.66	1.44	1.74
T17	1.66	1.66	1.33	1.33	1.33	1.11	1.40
T18	1.66	1.66	1.55	1.55	1.55	1.33	1.55
T19	1.66	1.66	1.33	1.33	1.33	1.11	1.40
T20	2.00	2.00	2.00	2.00	2.00	1.66	1.94
T21	2.33	2.33	1.77	1.66	1.55	1.22	1.81
T22	1.66	1.66	1.33	1.33	1.33	1.22	1.42
T23	1.66	1.66	1.00	1.00	1.00	0.89	1.20
T24	1.66	1.66	1.33	1.33	1.33	1.00	1.39
T25	1.33	1.33	1.33	1.33	1.33	1.22	1.31
Mean	1.88	1.87	1.59	1.49	1.47	1.28	1.59
F	88.76**	175.93**	60.07**	31.24**	22.69**	11.64**	26.45**
SE	0.045	0.032	0.055	0.054	0.058	0.081	0.064
CD	0.127	0.09	0.158	0.153	0.165	0.231	0.180

F (period) = 56.66** CD (period) = 0.088

F(Period x Treatment) = 1.263 CD (Period x Treatment) = 0.441

** Significant at 1 percent level

The essential oil content decreased with an increase in time (period). No significant difference in essential oil content were observed during the first, second, fourth and fifth periods.

4.2.5 Oleoresin content at different periods (%)

The data on oleoresin content at different periods were analysed separately and mean values are presented in the Table 5.

The results showed that during the first period the oleoresin content ranged from 2.44% to 5.89%. The treatment T_1 recorded a maximum of 5.89%. The treatment T_8 recorded 5.69% which ranked second and was on par with T_5. The treatment T_7 recorded 5.3% which ranked third was on par with T_3 and T_2. The treatment T_3 which recorded an oleoresin content of 5.11% was on par with T_2, T_{20}, T_4 and T_9 . The minimum oleoresin content of 2.44% was recorded by T_{15}.

The results showed that during the second period the oleoresin content ranged from 2.44% to 5.89%. The treatment T_1 recorded a maximum of 5.89% and the treatment T_8 recorded 5.69% that ranked second and was on par with the treatment T_5. The treatment T_7 recorded 5.3% that ranked third and the

treatment T_4 recorded a value of 5% which was on par with T_2, T_9 and T_3. The treatment T_{20} recorded an oleoresin content of 4.66% which ranked fifth.

The results showed that during the third period the oleoresin content ranged from 1.77 to 5.44%. Treatment T_1 recorded a maximum of 5.44% followed by T_8 which recorded 5% that ranked second and was on par with T_3, T_5, T_7 and T_{20}. The treatment T_3 with a value of 4.89% was on par with the treatments T_5, T_7, T_{20} and T_2. The treatment T_7 with a value of 4.66% was on par with the treatments T_{20}, T_2, T_4, and T_6. The treatment T_4 with a value of 4.44% was on par with T_6 and T_9 which recorded oleoresin content of 4.33% and 4.11% respectively. The least oleoresin content was noticed when the ginger was sliced, boiled and coated before drying (T_{25}).

The results showed that during the fourth period the oleoresin content ranged from 1.66 to 5%. The treatment T_8 recorded a maximum of 5%. This was on par with the treatments T_1 T_3, T_5 and T_{20}. The treatment T_3 recorded a value of 4.80% which was on par with T_5, T_{20}, T_2, T_4 and T_7. The treatment T_{20} recorded a value of 4.55% and was on par with the treatmentsT_2, T_4, T_7, T_6 and T_9 with a value of 4.11%.

During the fifth period oleoresin content ranged from 1.44% to 4.94%. The treatment T_1 recorded the maximum (4.94%) which was on par with T_8, T_3, T_5 and T_{20}. The treatment T_3 with a value of 4.75% was on par with the treatments T_5, T_{20}, T_2 and T_4. The treatment T_5 with a value of 4.58% was on par with T_{20}, T_2, T_4, T_7 and T_6. The treatment T_6 with a value of 4.36% was on par with the treatments T_4, T_7, T_6 and T_9 which recorded a value of 3.83 %.

The results showed that the during the sixth period the oleoresin content ranged from 1.33% to 4.88%. The treatment T_1 with a value of 4.88% was on par with T_8 that ranked first. The treatment T_3 with a value of 4.44% was on par with T_5 and T_2. The treatment T_2 with a value of 4.22% was on par with T_4, T_9 and T_{20}. The treatment T_9 with a value of 3.75% was also on par with T_7 and T_6 which recorded a value of 3.5%.

The pooled analysis of the data revealed that interaction between periods and treatments was not significant. The data, further showed that there was a progressive reduction in oleoresin content in all the treatments. The treatment combination which included boiling had resulted in the maximum reduction in oleoresin content followed by scraping and splitting treatment combinations.

Table. 5 Percentage of oleoresin at different periods

Treatments	PERIODS (BIMONTHLY) I	II	III	IV	V	VI	Pooled mean
T1	5.89	5.89	5.44	4.92	4.94	4.88	5.33
T2	5.11	5.00	4.55	4.42	4.36	4.22	4.61
T3	5.11	4.89	4.89	4.80	4.75	4.44	4.81
T4	5.00	5.00	4.44	4.36	4.25	4.00	4.51
T5	5.60	5.60	4.89	4.66	4.58	4.22	4.93
T6	4.44	4.33	4.33	4.11	4.08	3.50	4.13
T7	5.30	5.30	4.66	4.33	4.08	3.67	4.56
T8	5.67	5.67	5.00	5.00	4.92	4.75	5.17
T9	5.00	5.00	4.11	4.11	3.83	3.75	4.30
T10	3.11	3.00	2.11	2.00	2.00	1.75	2.33
T11	3.89	3.89	3.66	3.44	3.12	2.83	3.47
T12	4.33	4.33	3.55	3.22	2.83	2.58	3.47
T13	3.60	3.60	3.44	3.33	3.33	3.11	3.40
T14	3.45	3.45	3.00	3.00	2.66	2.44	3.00
T15	2.44	2.44	2.00	2.00	1.92	1.67	2.08
T16	4.00	4.00	3.33	2.89	2.42	2.17	3.13
T17	4.33	4.33	3.22	3.00	2.83	2.33	3.34
T18	4.00	4.00	3.22	3.22	3.08	2.92	3.41
T19	4.00	4.00	3.11	3.00	2.42	2.08	3.10
T20	5.00	4.66	4.66	4.55	4.44	4.11	4.57
T21	3.22	3.00	3.00	3.00	2.42	2.33	2.83
T22	4.00	4.00	3.00	3.00	2.17	1.92	3.01
T23	4.00	4.00	3.33	3.22	3.33	3.08	3.49
T24	2.67	2.67	2.22	2.22	2.17	1.92	2.31
T25	2.67	2.67	1.77	1.66	1.44	1.33	1.92
Mean	4.23	4.19	3.64	3.50	3.29	3.04	
F	163.15**	237.09**	73.22**	33.48**	30.82**	113.67**	119.01**
SE	0.077	0.063	0.119	0.169	0.190	0.099	0.091
CD	0.218	0.180	0.339	0.479	0.541	0.280	0.251

4.2.6 Crude fibre at different periods (%)

The data on crude fibre content at different periods were analysed seperately and mean values are presented in the Table 6.

The results showed that there was significant difference among treatments. During the first period the crude fibre content ranged from 5.44% to 6.66%. The treatment T_{24} recorded a minimum of 5.44% which was on par with T_{25}, T_{15}, T_{18}, T_{22} and T_{14}. But T_{15} with a value with 5.55 % was on par with T_{18}, T_{22}, T_{14}, T_{13}, T_{10}, T_{21} and T_{23}. The treatment T_3 with a value of 6.33% was on par with T_{19}, T_{20}, T_1 and T_2 with a maximum value of 6.66%.

The results further showed that during the second period the crude fibre content ranged from 5.44%, 6.44%. The treatment T_{22} recorded a minimum of 5.44% which was on par with T_{24}, T_{25} T_{15}, T_{18}, T_{14}, T_{19} and T_{21}.
The treatment T_1 with a highest value of 6.44 % was on par with T_2, T_3, T_{11}, T_8, T_{20}, T_4, T_5, T_9, T_{17} and T_7 with a value of 6.11%.

During the third period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded a minimum of

5.22% which was on par with T_{18}, T_{24}, T_{25} and T_{15}. The treatment T_{18} recorded a value of 5.44% and was on par with T_{24}, T_{25}, T_{15}, T_{14}, T_{16}, T_{19} and T_{21}. The treatment T_{10}, with a value of 5.89% was on par with T_{12}, T_{13}, T_{6}, T_{23}, T_{7}, T_{17}, T_{20}, T_{9}, T_{11}, T_{3}, T_{2}, T_{1}, T_{8}, T_{5} and T_{4}.

The results also showed that at the fourth period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded a minimum of 5.22% was on par with T_{18}, T_{24}, T_{25} and T_{16}. The treatment T_{18} recorded a value of 5.44% and was on par with T_{24} T_{25} T_{15} T_{14}, T_{16}, T_{19} and T_{21}. The treatment T_{10} with a value of 5.89% was on par with T_{12}, T_{13}, T_{6}, T_{23}, T_{7}, T_{17}, T_{8}, T_{20}, T_{9}, T_{11}, T_{3}, T_{1}, T_{2}, T_{5} and T_{4}.

During the fifth period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded a maximum of 5.22% which was on par with T_{25}, T_{18}, T_{24} and T_{15}. The treatment T_{18} with a value of 5.44% was on par with T_{24}, T_{15}, T_{14}, T_{16}, T_{19} and T_{21}. The treatment T_{10} with a value of 5.89% was on par with T_{12} T_{13}, T_{6}, T_{17}, T_{23}, T_{7}, T_{20}, T_{9}, T_{8}, T_{11}, T_{8}, T_{3}, T_{1}, T_{4} and T_{2}.

The crude fibre content during the *six*th period was found to range from 5.22% to 6.11%. The treatment T_{22} with a

Table 6 Percentage of crude fibre at different periods

Treatments	PERIODS (BIMONTHLY) I	II	III	IV	V	VI	Pooled mean
T1	6.66	6.44	6.22	6.22	6.22	6.11	6.31
T2	6.66	6.33	6.22	6.22	6.22	6.11	6.29
T3	6.33	6.22	6.11	6.11	6.11	6.11	6.16
T4	6.22	6.22	6.22	6.22	6.22	6.00	6.18
T5	6.22	6.22	6.22	6.22	6.11	5.88	6.14
T6	6.11	5.89	5.89	5.89	5.89	5.88	5.92
T7	6.22	6.11	6.11	6.00	6.00	6.00	6.07
T8	6.22	6.22	6.22	6.11	6.11	6.00	6.15
T9	6.22	6.11	6.11	6.11	6.00	5.89	6.07
T10	5.89	5.89	5.89	5.89	5.89	5.88	5.89
T11	6.22	6.22	6.11	6.11	6.11	6.00	6.13
T12	6.00	5.89	5.89	5.89	5.89	5.77	5.89
T13	5.88	5.89	5.89	5.89	5.89	5.88	5.89
T14	5.77	5.77	5.77	5.77	5.77	5.77	5.77
T15	5.55	5.55	5.55	5.55	5.55	5.44	5.53
T16	6.00	5.89	5.77	5.77	5.77	5.66	5.81
T17	6.22	6.11	6.11	6.00	5.88	5.77	6.02
T18	5.55	5.55	5.44	5.44	5.44	5.44	5.48
T19	6.33	5.77	5.77	5.77	5.77	5.66	5.85
T20	6.33	6.22	6.11	6.11	6.00	5.77	6.09
T21	5.89	5.77	5.77	5.78	5.78	5.77	5.79
T22	5.55	5.44	5.22	5.22	5.22	5.22	5.31
T23	5.89	5.89	5.89	5.89	5.89	5.77	5.87
T24	5.44	5.44	5.44	5.44	5.44	5.44	5.44
T25	5.44	5.44	5.44	5.44	5.22	5.22	5.37
Mean	6.03	5.94	5.90	5.88	5.86	5.78	
F	5.40**	5.40**	4.34**	5.07**	4.95**	2.26**	8.16**
SE	0.149	0.128	0.141	0.126	0.130	0.170	0.099
CD	0.423	0.363	0.400	0.358	0.369	0.483	0.277

F (Period) = 3.02* F (Period x Treatment) = 0.113 NS

NS - Non significant ** Significant at 1 percent level

value of 5.22% was on par with T_{25}, T_{15}, T_{18}, T_{24}, T_{16} and T_{19}. The treatment T_{16} with a value of 5.66% was on par with T_{19}, T_{12}, T_{14}, T_{17}, T_{20}, T_{21}, T_{23}, T_{6}, T_{10}, T_{13}, T_{5}, T_{9}, T_{7}, T_{11}, T_{8}, T_{4}, T_{3}, T_{1} and T_{2}.

The progressive reduction in crude fibre content was not significant. However the treatment combinations having boiling as a component resulted in lesser crude fibre content.

Pooled analysis of the date revealed that effect of treatments over periods was not significant.

4.2.7 Observations on attack of pests/disease

During the first period, attack of Book lice- Granthakita cuttackae Behura and Dash was noticed in all the replications of T_{7}, T_{9}, T_{11}, T_{12} and T_{16}. The attack was not severe.

4.2.8 Observations on External/Internal colour difference

The change in colour for various treatments after processing was recorded and are presented in the Table 7. There was no colour change in any treatment over the periods. (Plate - I-IX).

Table 7 External/internal colour change due to processing treatments.

Treatments	External colour	Internal colour
T_1	Brown	White
T_2	Dark brown	White
T_3	Brown	White
T_4	Brown	Light brown
T_5	Brown	Pinkish brown
T_6	Brown	Very dark brown
T_7	White coating	White
T_8	Dark brown	White
T_9	Dark brown	Pinkish white
T_{10}	Very dark brown	Very dark brown
T_{11}	White coating	White
T_{12}	Light brown	White
T_{13}	Brown	White
T_{14}	Brown	Pinkish white
T_{15}	Very dark brown	Very dark brown
T_{16}	White coating	White
T_{17}	Brown	Pinkish brown
T_{18}	Very dark brown	Very dark brown
T_{19}	White coating	White
T_{20}	White coating	Pinkish brown
T_{21}	White coating	Very dark brown
T_{22}	Very dark brown	White
T_{23}	Light brown	Pinkish brown
T_{24}	White coating	Very dark brown
T_{25}	White coating	Very dark brown

Table 8 Weight loss due to storage (g)

Treatments	Periods (Bimonthly)					
	I	II	III	IV	V	VI
T_1	360	360	360	360	360	360
T_2	325	325	325	325	323.5	323.5
T_3	315	315	315	310	310	310
T_4	330	330	330	327	327	327
T_5	325	325	325	325	325	324
T_6	345	345	345	345	345	345
T_7	310	310	310	310	310	310
T_8	310	310	310	310	310	310
T_9	310	310	310	310	310	310
T_{10}	325	325	325	325	325	322
T_{11}	300	300	300	300	300	297
T_{12}	305	305	305	305	305	305
T_{13}	305	305	305	305	305	305
T_{14}	310	310	310	310	307	307
T_{15}	310	310	310	310	310	310
T_{16}	305	305	305	305	305	305
T_{17}	310	310	310	310	310	307
T_{18}	305	305	305	305	305	305
T_{19}	320	320	320	320	320	320
T_{20}	340	340	340	340	340	340
T_{21}	340	340	340	340	340	340
T_{22}	342.50	342.50	340	340	340	340
T_{23}	260	260	258	258	258	258
T_{24}	260	260	260	260	260	260
T_{25}	300	300	300	295	295	295

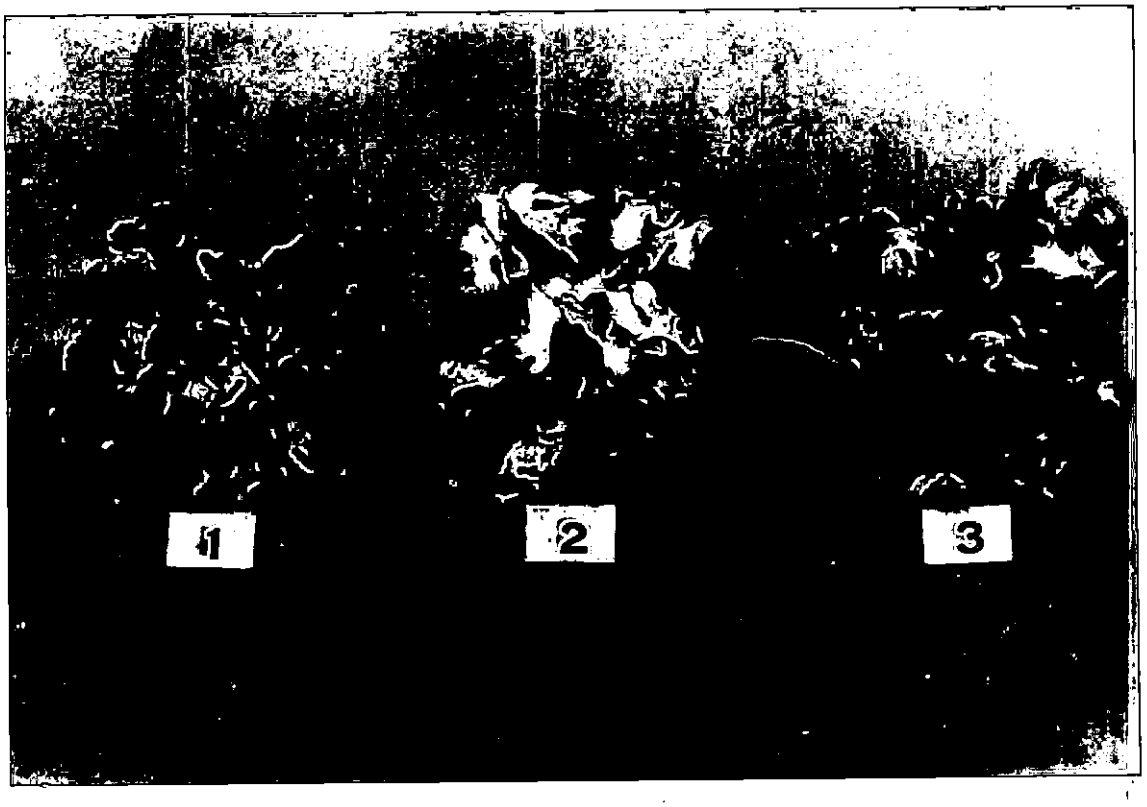

PLATE-I

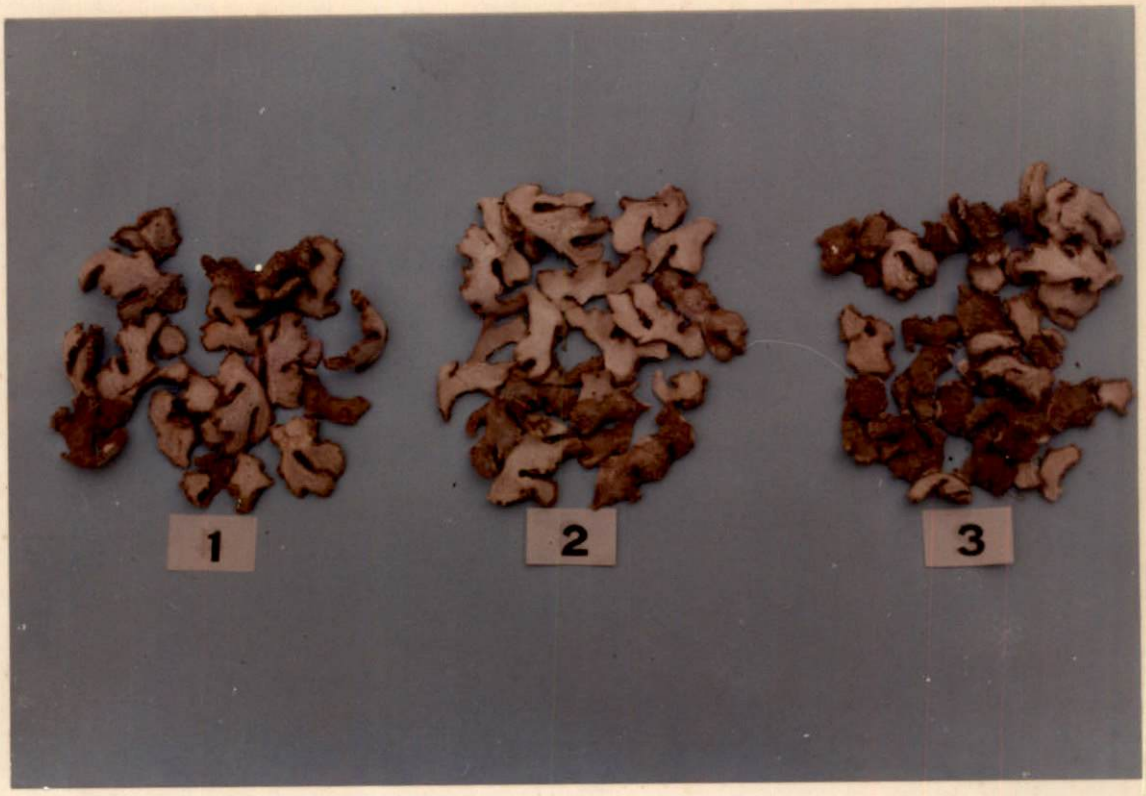

PLATE-I

1. Splitting and drying (T_2)
2. Splitting, scraping and drying (T_8)
3. Splitting, blanching and drying (T_9)

TE-II

4. Splitting, boiling, coating and drying (T_{22})
5. Splitting, coating and drying (T_{11})
6. Splitting, boiling and drying (T_{10})

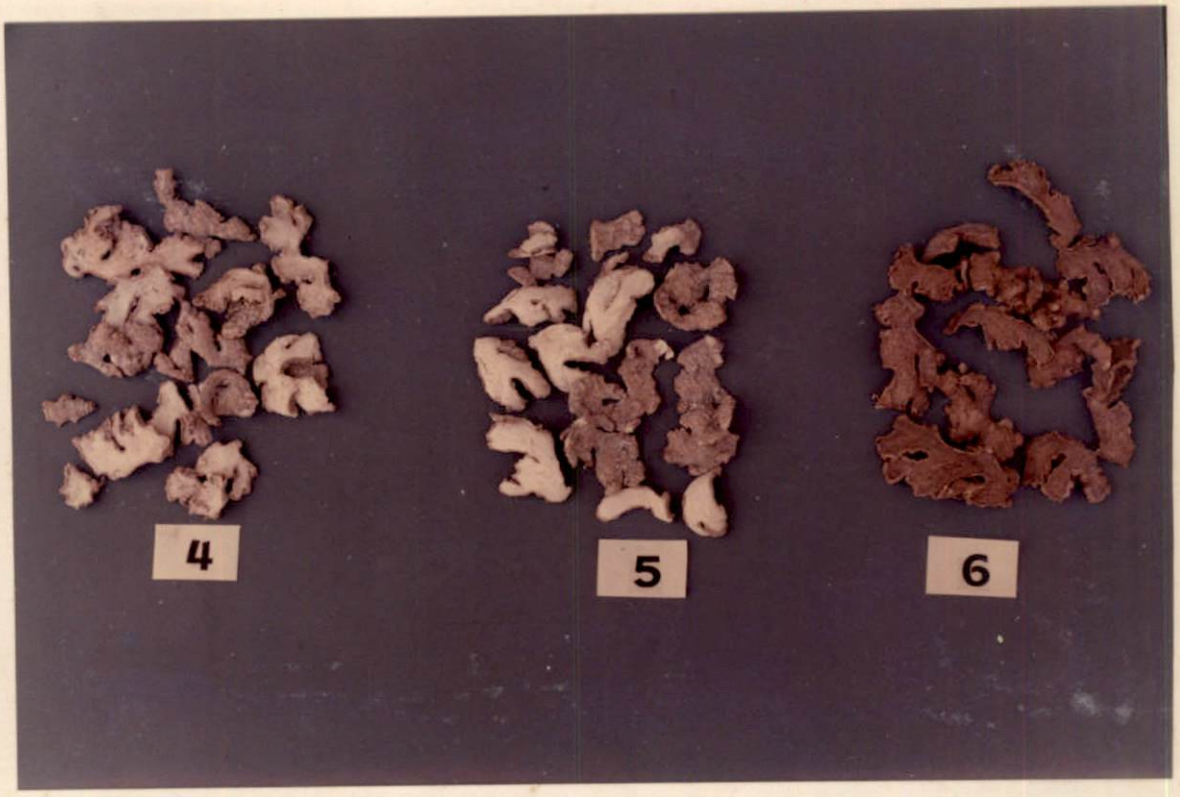

PLATE-II

ATE-III

7. Scraping and drying (T_3)
8. Scraping, splitting and drying (T_{12})
9. Scraping, blanching, and drying (T_{14})

PLATE-III

PLATE-IV

10. Scraping, boiling, coating and drying (T_{24})
11. Scraping, coating and drying (T_{16})
12. Scraping, boiling and drying (T_{15})

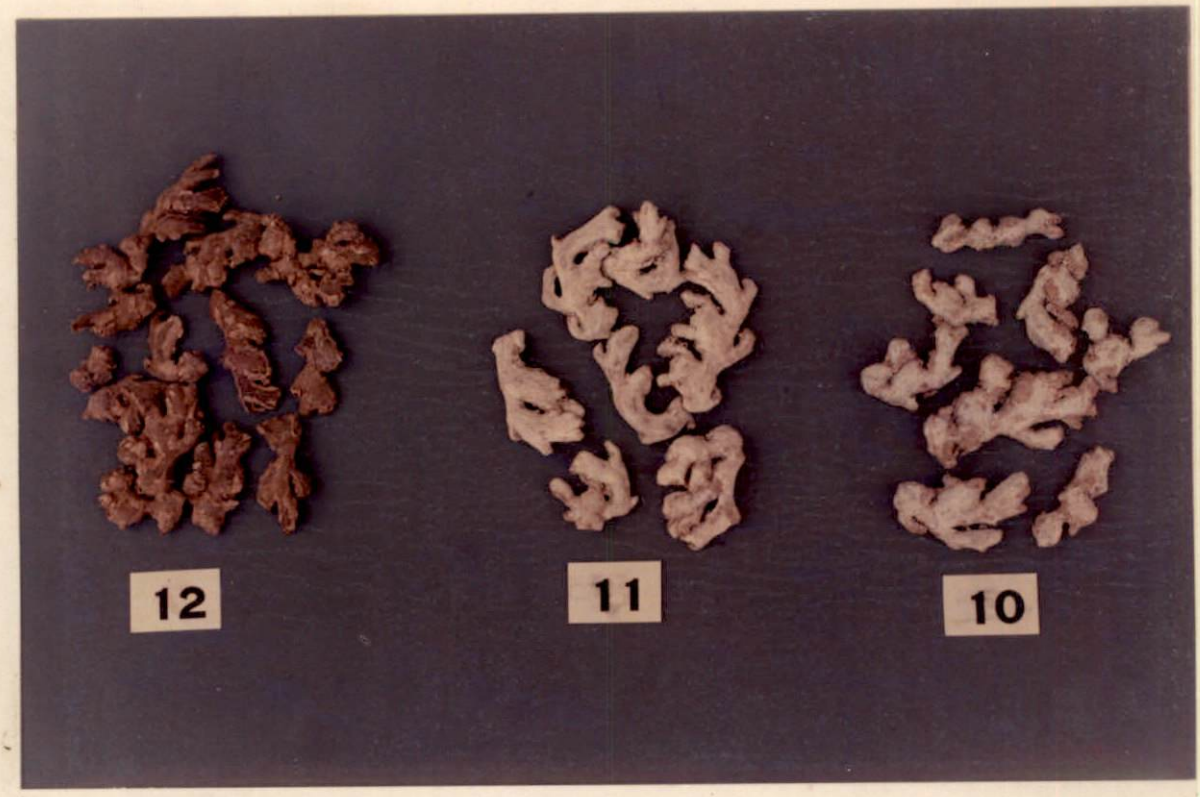

PLATE-IV

PLATE-VII

18. Scraping, slicing and drying (T_{13})
19. Slicing, coating and drying (T_{19})

PLATE-VI

PLATE-VI

16. Slicing, boiling, coating and drying (T_{25})
17. Scraping, slicing, blanching and drying (T_{23})

PLATE-V

PLATE-V

13. Slicing and drying (T_4)
14. Slicing, balancing and drying (T_{17})
15. Slicing, boiling and drying (T_{18})

PLATE-VII

LATE-IX

23. Coating and drying (T_7)
24. Unpealed and drying (T_1)
25. Boiling, coating and drying (T_{21})

LATE-IX

23. Coating and drying (T_7)
24. Unpealed and drying (T_1)
25. Boiling, coating and drying (T_{21})

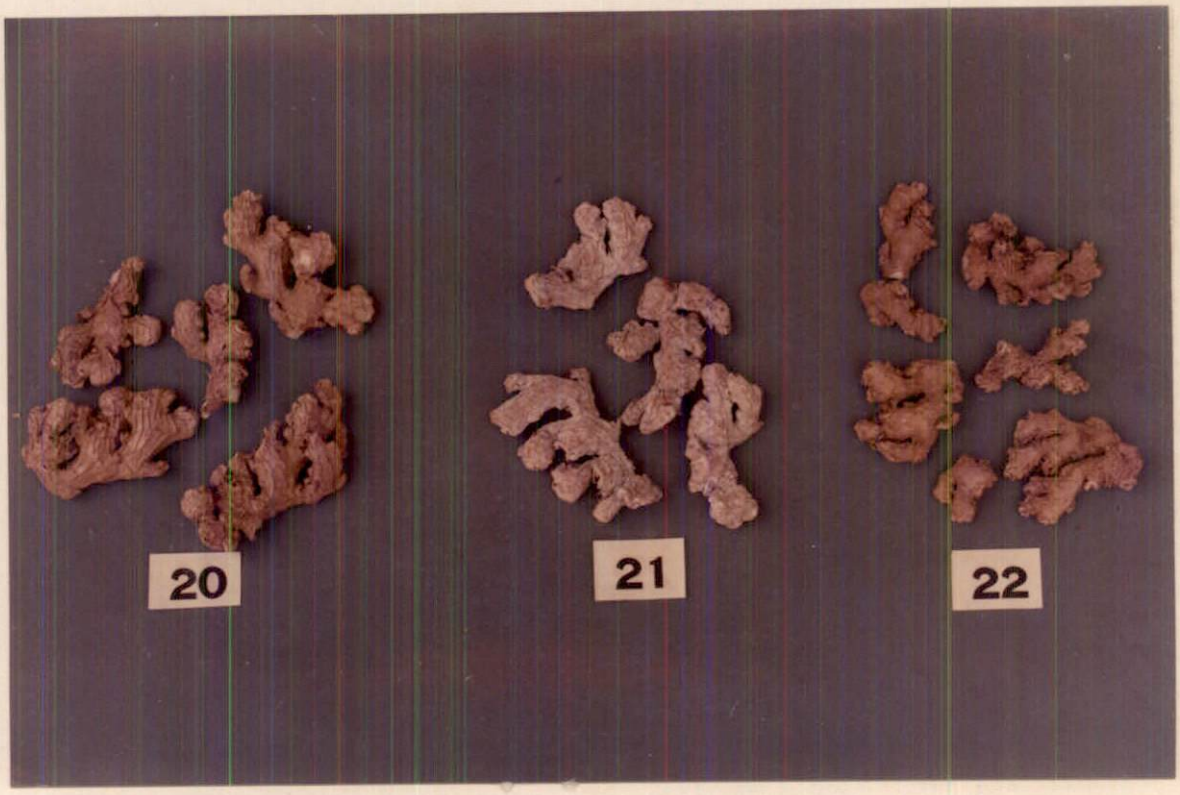

PLATE-VIII

LATE-VIII

20. Blanching and drying (T_5)
21. Blanching, coating and drying (T_{20})
22. Boiling and drying (T_6)

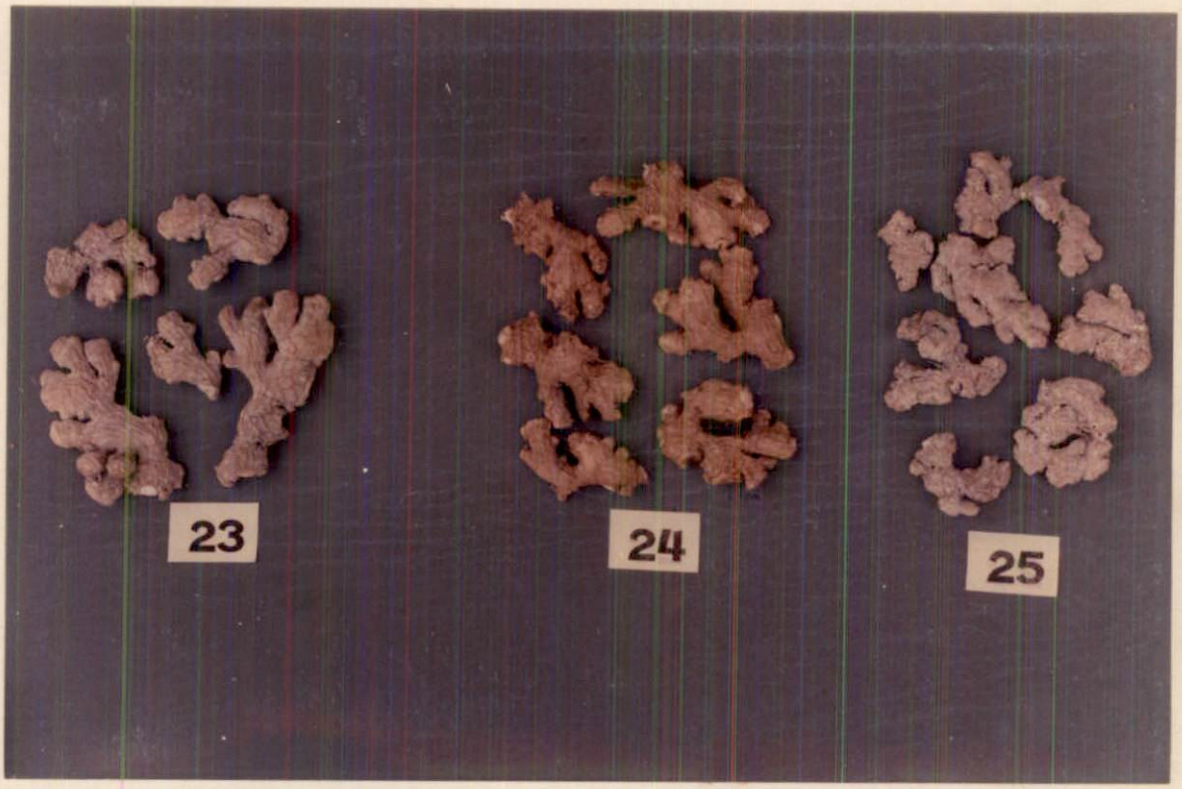

PLATE-IX

The internal colour of the rhizomes in the treatment combinations having boiling as one of the components was very dark brown throughout the period.

4.2.9 Weight loss due to storage

The data presented in Table 8 revealed that due to storage of rhizomes the weight loss was rather negligible.

DISCUSSION

5 DISCUSSION

The two traditional dry ginger products exported from India are scraped dry ginger and bleached/coated dry ginger. In the case of these traditional products from India no effort is seen made to improve the quality and appearance to catch better export. So the present investigation was undertaken to assess the effect of various methods like scraping, slicing, bleaching, boiling and coating and their combinations on the yield and quality of dry ginger, storage life and their effects on storage pests and diseases.

In this study one kilogramme fresh ginger of the variety Kuruppampady was taken for processing after initial evaluvation of quality like moisture (%), essential oil (%), oleoresin (%) and crude fibre (%) . After processing, the dried materials were stored in polythene lined gunny bags for one year. During storage the samples were analysed for quality aspects, colour difference, storage pests and diseases at bi-monthly intervals.

The results of the present study showed that before processing the average values for moisture content, essential oil content, oleoresin content and crude fibre content were 68.80 %, 3.06%, 5.80% and 6.67% respectively.

After processing, the products were analysed for different quality parameters and the results were discussed here under.

5.1 Dry ginger recovery (%)

The dryage due to different treatment revealed that the rhizomes when dried without any treatment got the maximum recovery of 36.17%, whereas in the scraped rhizomes, split rhizomes, sliced rhizomes the percentage recovery was proportionately reduced.

The percentage recovery of dry ginger ranged from a minimum of 25% to a maximum of 36.17%, and also there was significant difference among the treatments.

Nybe and Nair (1978) reported the dry ginger recovery of 23% for the variety Kuruppampady whereas maximum recovery of 25.09% dry ginger was noticed in variety Tura.

The dry ginger recovery in the present study was more than that has been reported earlier. This was also evident in the moisture estimation of fresh material which was to the tune of 68.80%. In otherwords the dry matter content of rhizomes was to the tune of 31.20%. The variation in dry

ginger recovery in the present study can be attributed to the treatment effects. Thus when ginger rhizome was dried without removing the skin it resulted in a higher recovery. In the normal case dry ginger is prepared only after scraping of the skin which resulted in a low recovery. This is reflected in a comparatively low recovery of 31.67% of dry ginger for the scraped ginger in the present study.

5.2 Number of days taken for drying

The data (Table 2) revealed a significant influence of processing methods on drying periods. This ranged from 4 days to 30 days.

The present study revealed that the size reduction of rhizomes by splitting, slicing etc reduced the number of days taken for proper drying. Drastically, sliced rhizomes took only 4 days. These results were found to be in accordance with the reports of Purseglove et al. (1981).

Shankaranarayana et al (1988) reported that peeled rhizomes were sundried to a moisute level of 10-12%. Generally, this took 20 to 25 days under good sunshine. He also indicated that the sliced rhizomes reduced the drying period.

Purseglove et al.(1981) also reported that splitting and slicing of whole rhizomes were done so as to accelerate drying.

5.3 Moisture content at different periods of storage (%)

The results showed that (Table 3) during initial periods, (first, second and third periods) all the treatments had 10% moisture. During the fifth period onwards there was significant difference among treatments. The treatment differences did not reveal any specific pattern in moisture content.

Pooled analysis of the data revealed that the interaction was not significant. It showed that the moisture content over periods did not differ significantly even though there was apparent differences among treatments as explained above. This can be related to the negligible weight loss during storage.

5.4 Essential oil content at different periods of storage (%)

The results showed that during the first period the essential oil content ranged from 1.25% to 3% and there was significant difference between treatments. The treatment T_1

recorded a maximum of 3%. This was followed by T_6 with 2.5% and was on par with T_4 and T_5.

During the second period also essential oil content ranged from 1.25% to 3%. The treatment T_1 recorded a maximum of 3% followed by 2.5% in T_6 which was on par with T_4 and T_5.

The results showed that during the third period the essential oil content ranged from 1% to 3%. The treatment T_1 recorded a maximum value of 3%. This was followed by T_4 (2.33%).

During the fourth period the essential oil content ranged from 1% to 2.22%. The treatment T_4 recorded a maximum of 2.22%. This was followed by T_1 with a value of 2% and was on par with T_5 and T_{20}.

During the fifth period the essential oil content ranged from 1% to 2%. The treatments T_1, T_5, T_4 and T_{20} recorded a maximum essential oil content of 2% each.

During the sixth period the essential oil content ranged from 0.87% to 2%. The treatment T_4 recorded a maximum of 2% which was on par with T_5 (1.89%).

Pooled analysis of the data revealed that the average essential oil content was not consistent over periods. So the average effect of treatments over the periods were tested against the interaction. Essential oil content decreased with an increase in time (period). No significant difference in essential oil content among treatments was noticed during the first , second, fourth and fifth periods.

The reports revealed that traditional drying methods can result in loss of some volatile oil (upto 2%) by evaporation and in the destruction of some of the heat sensitive pungent constituents. Pungency reduction is usually less with split (or sliced) than with whole rhizome, as they took longer periods for drying (Puresglove et al. 1981). They also reported that prolonged storage of ginger can result in a deterioration of its aroma,flavour and pungency.

Akhila and Tewari (1984) reported that the yield of essential oil varies from 1.5 to 3%, depending upon a number of factors such as ginger cultivar, stage of maturity at harvest, the method of preparation and drying, its age and to some extent upon the distillation method.

The difference in oil content can be attributed to the method of preparation of the end product as suggested by

Akhila and Tewari (1984) as the other factors are common to all the treatments. The reduction in oil content during storage may be due to the evaporation of oil due to prolonged storage. This is in conformity with the report of Purseglove et al. (1981).

5.5 Oleoresin content at different periods (%)

The results revealed that there was significant difference among the treatments.

During the first period the oleoresin content ranged from 2.44% to 5.89%. The treatment T_1 recorded a maximum value of 5.89%. The treatment T_8 recorded 5.67% and was on par with T_5. The treatment T_7 recorded 5.3% that ranked third which was on par with T_3 and T_2.

During the second period the oleoresin content ranged from 2.44% to 5.89%. The treatment T_1 recorded a maximum of 5.89% and T_8 that ranked second recorded 5.67% which was on par with treatment T_5. The treatment T_7 which ranked third recorded an oleoresin content of 5.3%.

During the third period the oleoresin content ranged from 1.77% to 5.44%. The treatment T_1 recorded a maximum of 5.44% followed by T_8 which recorded 5% (rank second) and was on par with T_3, T_5, T_7 and T_{20}.

During the fourth period the oleoresin content ranged from 1.66% to 5%. The treatment T_8 recorded a maximum of 5% and this was on par with T_1, T_3, T_5 and T_{20}.

During the fifth period the oleoresin content ranged from 1.44% to 4.94%. The treatment T_1 recorded a maximum of 4.94% which was on par with T_8, T_3, T_5 and T_{20}.

During the sixth period the oleoresin content ranged from 1.33% to 4.88%. The treatment T_1 with a value of 4.88% was on par with T_8 (rank first). The treatment T_3 with a value of 4.44% was on par with T_5 and T_2.

Pooled analysis revealed that interaction between periods and treatments was not significant. At the same time there was progressive reduction in the oleoresin content in all the treatments. The treatment combinations which included boiling resulted in the maximum reduction in oleoresin content followed by scraping and splitting treatment combinations.

Different workers expressed different reasons for reduction in oleoresin in various ginger products. The extent of peeling was the major reason attributed to the reduction in oleoresin by Elsdon and Mayne (1937). Connell (1969) reported that gingerols are susceptible to chemical transformation to less pungent degradation products and that these reactions can occur by poor handling during the preparation, storage and utilization of dried ginger and its oleoresin with consequent deterioration of quality. He also showed that the decrease of gingerol and increase of shogaols, are due to drying conditions and storage of oleoresin. These progressive changes during storage in the pungent constituents of ginger have been confirmed by recent quantitative studies by Ananthakrishna and Govindarajan (1974). This has been further confirmed by Narasimhan and Govindarajan (1978).

Thus the difference in the oleoresin content among the treatments can be attributed to the extent of pealing and handling during processing. When ginger rhizomes were dried without pealing/scraping it resulted in comparatively higher oleoresin content. This is because the oleoresin bearing cells are not exposed and thus whatever oleoresin present in the rhizomes escaped, thereby there was higher oleoresin content in T_1. Further, though there was progressive reduction in oleoresin content due to storage in all the treatments, T_1

upheld its superiority over other treatments. This was further confirmed by Mangalakumari et al. (1984), who found that gingerol bearing cells were found to be distributed uniformly in the cortex and pith of the rhizome. Gingerol was seen localised in isolated cells situated among a group of hyaline cells. No vascular supply was noticed in connection with gingerol cells and essential oil cells. The localisation of gingerol cells and essential oil cells in the plant tissue is independent of one another.

As the oleoresin bearing cells are exposed due to deep scraping there was reduction in oleoresin content in scraping treatments. But in the present study this trend was not consistent. This is due to the fact that scraping was carried out manually using bamboo splits and thereby scraping was not uniform. Thus the inconsistency in the oleoresin content in the scraping treatments can be attributed to this uneven scraping.

The size reduction by slicing reduced the drying time drastically, which would have resulted in a higher oleoresin content, but this was also not clearly evident in this study. The favourable effect of size reduction was reported by Purseglove et al (1981). The reduction in oleoresin content

in slicing treatment in the present study can be attributed to poor handling during drying. The low oleoresin content in the treatments where boiling was a component can be attributed to the deterioration of oleoresin due to prolonged heat treatment of rhizomes. This was confirmed by the finding of chen at al (1986) and Mc Hale at al (1989).

Progressive reduction in oleoresin content in the various treatments during storage can be attributed to the degradation of oleoresin and its constituents. This is in conformity with the finding of Narasimhan and Govindarajan (1978). Purseglove et al (1981) who supported the view that prolonged storage can result in the deterioration of aroma, flour and pungency .

5.6 Crude fibre content at different periods (%)

The results showed that there was significant difference among treatments at different periods.

During the first period the crude fibre content ranged from 5.44% to 6.66%. The treatment T_{24} recorded a minimum of 5.44% and was on par with T_{25}, T_{15}, T_{18}, T_{22} and T_{14}.

During the second period the crude fibre content ranged from 5.44% to 6.44%. The treatment T_{22} recorded the minimum of 5.44% which was on par with T_{24}, T_{25}, T_{15}, T_{18}, T_{14}, T_{19} and T_{21}.

During the third period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded the minimum of 5.22% and was on par with T_{18}, T_{24} T_{25} and T_{15}.

During the fourth period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded the minimum of 5.22% which was on par with T_{18}, T_{24}, T_{25} and T_{15}.

During the fifth period the crude fibre content ranged from 5.22% to 6.22%. The treatment T_{22} recorded the minimum of 5.22% which was on par with T_{25}, T_{18}, T_{24} and T_{15}.

During the sixth period the crude fibre content ranged from 5.22% to 6.11%. The treatment T_{22} with a value of 5.22% was on par with T_{25}, T_{18}, T_{24}, T_{16} and T_{19}.

The present study revealed that compared to single treatment a combination of treatments may reduce the crude fibre content and the treatment combinaion having boiling as a component resulted in lesser crude fibre content.

Pooled analysis of the data revealed that effect of treatments over the periods was not significant.

5.7 Pest/disease attack

During the first period alone the attack of book lice - Granthakith cuttackae was noticed in all the replications of T_7, T_9, T_{11}, T_{12} and T_{16}. The attack of this pest was not severe. Actually the pest was noticed on the surface layer only. No other pest attack was noticed in any of the treatments during storage. Absence of any serious attack of pests and diseases can be attributed to the better storage conditions under which the products were stored.

5.8 External/internal colour difference

The colour change after the processing was recorded and given in the Table 7. Over a period of one year there was no colour change. However internal colour of the dried rhizomes in treatment combinations having boiling as one of the components were very dark brown throughout the period. At the same time blanching resulted in a pinkish colouration of the products whereas other treatments had normal colour both external and internal. This showed that if ginger products are stored after proper drying, it can be stored long without deterioration of colour.

5.9 Weight loss due to storage

The results in the Table 8 showed that the weight loss due to storage was rather negligible. This may be due to the fact that the samples were dried to 10 per cent moisture level and then packed in polythene lined gunny bags. Further, there was no pest attack or disease incidence. Thus these factors did not cause any damage.

SUMMARY

6 SUMMARY

6.1 Studies were undertaken at the College of Agriculture, Vellayani during 1988-'90 to evaluvate the different processing methods and storage on the quality of ginger. In this study one kilogramme fresh ginger of the variety Kuruppampady was taken for processing after initial evaluvation of quality aspects like moisture, essential oil, oleoresin and crude fibre . The treatments included different processing methods like scraping, splitting, slicing, blanching, boiling and their combinations. After processing, the dried materials were stored in polythene lined gunny bags for one year. During these periods samples were analysed for quality aspects, colour differences, storage pests and diseases attack at bimonthly intervals.

6.2 Before processing the contents of moisture, essential oil , oleoresin and crude fibre were 68.80 per cent, 3.06 per cent, 6.00 per cent and 6.67 per cent respectively.

6.3 Among the various treatments a low recovery (31.67 %) of dry ginger was obtained for the scraped ginger.

6.4 The number of days taken for drying ranged from 4 days to 30 days. The sliced rhizomes took only 4 days for drying.

Ginger rhizomes that did not receive any special treatment took 30 days for drying.

6.5 In this study weight loss due to storage was negligible.

6.6 During the first, second and third periods all the treatments had 10 per cent moisture. During the fifth period onwards there was significant difference among treatments. The treatment differences did not reveal any specific pattern in moisture content.

6.7 With regard to essential oil content no significant difference in treatments were noticed during the first, second, fourth and fifth periods. Essential oil content decreased with an increase in time. The treatments slicing and drying (T_4), blanching and drying (T_5), unpealed and drying (T_1), scraping and drying (T_3) and splitting and drying (T_2) were found to be the best for longer storage.

6.8 There was progressive reduction in the oleoresin content of all the treatments. The treatment combinations which included boiling resulted in the maximum reduction in oleoresin content followed by combinations of scraping and splitting treatment .

6.9 With regard to crude fibre content there was significant difference among treatments in different periods. The present study revealed that compared to single treatments a combination of treatments especially when boiling as a component reduced the crude fibre content. The effect of treatments over periods was not significant.

6.10 During the first period alone the attack of book lice - Granthakitha cuttacke was noticed in the treatments viz; coating and drying (T_7), splitting, blanching and drying (T_9), splitting coating and drying (T_{11}), scraping, splitting and drying (T_{12}) and Scraping, coating and drying (T_{16}). The incidence of this pest was not found to be severe. No other storage pest attack or disease incidence was noticed.

6.11 The treatment combinations having boiling as one of the components were very dark brown throughout the period and at the same time blanching resulted in a pinkish colouration of the products.

6.12 Ginger rhizomes when sliced and dried took the minimum period for drying and it resulted in the production of normal coloured product and also in comparable in quality aspects.

6.13 Hence slicing, drying and storage of ginger rhizomes is an alternate method for processing of ginger.

6.14 Further standardization of scraping, slicing, drying and storage is needed to perfect this method.

6.15 Sliced material has an added advantage of size reduction and is further advantageous for powdering. However the consumers preference has to be evaluated before this processing method is advocated among the farmers.

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STANDARDIZATION OF POSTHARVEST PROCESSING OF GINGER (*Zingiber officinale* Roscoe)

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ABSTRACT OF A THESIS
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ABSTRACT

Investigation on standardization of post-harvest processing of ginger (Zingiber officinale Roscoe) was carried out at the Department of Horticulture, College of Agriculture, Vellayani during 1988-90. Ginger rhizomes were processed to study the effect of various methods like scraping, slicing, blanching, boiling, coating and their combinations on the yield and quality of dry ginger, storage life and also on storage pests and diseases adopting CRD.

In this study among the various treatments low recovery (31.6 per cent) of dry ginger was obtained for scraped ginger. The sliced rhizomes took only four days for drying.

Significant difference in moisture content was evident during fifth period onwards and these defferences did not reveal any specific pattern in moisture content.

The essential oil content decreased with an increase in time. The treatments slicing and drying (T_4), blanching and drying (T_5), unpealed and drying (T_1) scraping and drying (T_3) and spliting and drying (T_2) were found to be the best for longer storage.

The oleoresin content also decreased with an increase in time and the treatment combinations which include boiling resulted in the maximum reduction in oleoresin content followed by combinations of scraping and spliting.

The present study revealed that compared to single treatment a combination of treatments especially when boiling as a component reduced the crude fibre content.

The ginger rhizomes when sliced and dried took the minimum period for drying and it resulted in the production of normal coloured product and also comparable in quality aspects. Hence slicing and drying of ginger rhizomes is an alternate method for processing of ginger.