GINGER PROCESSING TO OLEORESIN- AN INDUSTRY WIDE STUDY REPORT

MODEL BUSINESS PLAN

SUBMITTED TO:

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1.0. INTRODUCTION

1.1. Ginger Crop – Background Information

Ginger (*Zingiber officinale*) is an herbaceous perennial plant belonging to the order *Scitamineae* and the family *Zingiberaceae*. It is a root crop and a typical herb extensively grown across the world for its pungent aromatic under-ground stem or rhizome which makes it an important export commodity in world trade (NEPC, 1999; Erinle, 1989; Ajibade & Dauda, 2005). The knobby rhizome is dug up when the 1 meter tall leaves and stems of the plant wither, which occurs between 6 and 12 months after planting.

![Figure 1: Ginger Plant (*Zingiber officinale*)](image1.png)  
![Figure 2: Ginger Rhizome](image2.png)

Ginger’s origin is not well established though it is generally thought to be a native of Asia, where it was first cultivated. It was also cultivated in the tropical regions of America. Ginger was introduced to Europe by Arab traders from Indian the first century AD. The Arabs also took the plant from India to East Africa in the thirteenth century while the Portuguese took it to West Africa and other part of the tropics in the sixteen century. Ginger was introduced to Nigeria in 1927. The spice was known in Germany and France in the ninth century and had become common in trade as pepper by the thirteenth century.
The Chinese and Indians however were probably the earliest cultivators. It is therefore safe to say that Ginger is believed to have originated from East Asia. It appears to have been used as a spice and medicine from early times by Indians and Chinese.

Ginger is an erect herbaceous plant with fibrous stem bearing creeping underground tuber or rhizome. Its Botanical name is *Zingiber officinale*. It is a crop that makes heavy demand on labour during cultivation and exhaust soils. It strives best on medium loams with a good supply of humours. It is cultivated as an annual crop, which is reproduced by means of cutting the rhizome (i.e. it is propagated vegetatively). The chemical composition of ginger makes it a very sought after spice. The ginger of commerce is the elongated, branched and pungent pseudo-stem (underground root-like stems) of the plant or rhizome. Ginger is grown over a wide area of the tropics, although the major production areas are in South and East Asia. In the early years of the twentieth century, the most widely known producers and exporters of ginger were China, Jamaica and Sierra Leon. A number of other countries have since emerged as important ginger exporters amongst which Nigeria and more recently Australia are the most notable.

1.2. **Ginger in Nigeria**

Ginger is grown in Nigeria generally in the Middle Belt States. The most notable are Kaduna, Plateaus, Niger and Nassarawa States in order of quantity produced. The production of ginger in Nigeria started vigorously in 1927, when an investigation was carried out to find a crop that would generate internal trade for the people of Southern Zaria Province (now Southern Kaduna), the traditional home of ginger production in Nigeria. The plant is now cultivated in different parts of Nigeria, though the major producing areas include Kaduna, Nassarawa, Sokoto, Zamfara, Akwa-Ibom, Oyo, Abia and Lagos states. Southern Kaduna still
remain the largest producers of fresh ginger in Nigeria in Kachia, Jabba, Jama’a and Kagarko Local Government Areas (Bernard, 2008). Nigeria ranked first in terms of the percentage of total hectares of ginger under cultivation but her contribution to total world output is too low compared to other countries. This can be attributed to the fact that most of production is undertaken by smallholder and traditional farmers with rudimentary production techniques and low yields. In addition, the smallholder farmers are constrained by many problems like the farmers do not see it as a business enterprise, therefore are not adequately focused on profit maximizing motive. (FAO, 2010).

The varieties produced in Nigeria are ‘Taffin Giwa’ and ‘Yatsun Biri’ which is higher in monoterpenes and oil, giving a more pungent aroma and pungency. Therefore it is usually preferred for the production of oils and oleoresins (KADP, 2000; Chukwu & Emehuie, 2003).

1.3. **Ginger Products, Components and Uses**

Ginger products, such as essential oil and oleoresin, are internationally commercialized for use in food and pharmaceutical processing. Essential oil is characterized by monoterpenes and sesquiterpenic compounds while the main pungent compounds in the oleoresin are a series of homologues called gingerols and shogaols.

In recent years, more and more pharmaceutical effects have been found on ginger. It can act as an aphrodisiac, a carminative, a rubifacient, an anti-asthmatic and as a stimulant to the gastrointestinal tract. Ginger is often used for the treatment of stomachaches, and cardiovascular and motor diseases. It also possesses anti-inflammatory activity and regulates bacterial growth, as well as providing protection for immune-depressed patients, such as individuals who are HIV positive.
Many active components have been found in ginger. The active component obtained from ginger is a high value-added product and due to such, there is continued research for improved extraction techniques that will lead to better quality extracts and greater yields.

Today, in food processing, the main use of spice oleoresins are in processed meat, fish, vegetables, soups, sauces, chutneys, dressings, cheeses as well as dairy products, baked foods, confectionery, snacks and beverages. Ginger oleoresin is important for its volatile oil as well as its non-volatile pungent oils. There is a great demand for ginger oleoresins abroad, especially for the production of alcoholic beverages, as well as in the production of gingerbread and drinks like ginger ale. Ginger oleoresin also has a huge demand in the Ayurvedic and pharmaceutical industries.

1.4. The Main Commercial forms of Ginger

Until the processing of ginger was introduced ginger entered the international market in the form of its three primary products namely:

a) Fresh (green) ginger

b) Preserved ginger

c) Dried (split or peeled) ginger

Ginger is however traded mainly in the two forms of fresh and dried. Preserved ginger is prepared from the immature rhizome while the more pungent and aromatic spice is prepared by harvesting and drying the mature rhizome. Fresh ginger, consumed as a vegetable, is harvested both when immature and mature.

1.4.1. Fresh Ginger

Because of the high water content of fresh ginger the trade in it is limited due to high cost of transportation and low resistance to spoilage due to heat humidity...
and handling. A larger proportion on the trade in fresh ginger occurs among the countries of Asia. The overall trade in fresh ginger in the international market is however insignificant. The value of fresh spices and herbs has led to greater attention o the factors affecting their perishability. Post harvest conditions that are suitable for one fresh herb may not be appropriate for another. Critical factors in determining the shelf life of fresh herbs and spices include temperature, humidity, and atmosphere, light and handling among others.

1.4.2. Preserved Ginger

Preserved ginger is prepared in some of the producing countries notably in China, Hong Kong, Australia and India. Two forms of processed preserved ginger entering the market are:

i. Preserved ginger in sugar syrup

ii. Dry or crystallized ginger: - this is ginger that has been impregnated with sugar syrup, dried and crated with crystalline sugar.

1.4.3. Dry Ginger

The dry ginger may be peeled or sliced before drying. The drying could be sun-dried or mechanically dried. The sun-dried ginger is more common in Nigeria and India. The sun dried ginger is inferior in quality to the mechanically dried because of impurities like sand, animal faeces foreign matter etc. The dried has been the form in which ginger is traded internationally in the whole or split forms. While flavour is the critical factor for the spices, cleanliness and the freedom from microbial contamination are also crucial elements of the spice quality. The traditional existing forms of drying ginger can be improved to increase the amount of value addition. Few modifications on the existing practice such as sorting, grading, cleaning, peeling in proper way; drying and packaging will gradually improve the quality of the end product. The spices are sold to
various spice companies for further processing, including cleaning, grinding, blending and packaging.

1.5. Why Ginger is processed

While ginger is grown only in some countries, it is sought for all over the world. Ginger is a seasonal crop and is perishable. Products like spice, oil and oleoresin can be made from the ginger. Ginger is harvested in large quantity during the season. Due to lack of processing facilities a large proportion of the production could be wasted.

Unprocessed ginger however contains extraneous matter such as insect parts and stone or support colonies of bacteria or fungi, when, they arrive from suppliers. Processor must treat these problems of contamination before the spices are put in the market. Ginger finds a good market potential the year round as it is used not only as a spice in preservations but also in confectionary, pharmaceuticals, soft drinks, soap processing industry, food, flavour, perfumery, confectionary and bakery and other industries.

The FDA and the American Spice Trade Association (ASTA) each have developed specifications for foreign material (defects) in imported spices. Both sets of guidelines recognize that spices need additional cleaning by processors after they arrive from suppliers. Processors use air separators gravity separators, and centrifugal separators to rid spices of foreign matter.

Microorganisms in spices can lead to spoilage or disease if the infected spices are incorporated into food products. Although microbial contamination is often attributed to the lack of good sanitary conditions in some countries where the spices are produced, even onion in powder grown and processed in the United States may have total plate count of 1 million/g. Spices that originate from plants that produce natural anti-microbial substances generally contain smaller bacterial
population. Cinnamon muster and nutmeg are examples of spices with low levels of bacteria.

1.5.1 Treatment for microbes

i. Treating the spices with ethylene oxide can reduce microbial counts by 90%. However, this gas has been classified as a carcinogen, and it can react with chlorides in foods to produce toxic and persistent chlorohydrins.

ii. Propylene oxide is an alternative to ethylene oxide but it is less effective at reducing microbes and also generates chlorohydrins.

iii. Sterilization by heat seriously degrades the flavour of spices.

iv. Microwave treatment of spices has been attempted but does not effectively reduce microbes’ levels.

v. Ultraviolet radiation does not have enough penetrating power to decontaminate spices.

vi. The most effective way to reduce or eliminate bacterial and fungal populations on spices and the least likely to cause flavour changes is to subject them to ionizing radiation. However such products must be labelled as “treated with radiation”. The spice industry is still leery for the public’s reaction to irradiated food. It’s a result, less that 1% of spices used in the processed foods are irradiated. No spices sold in the retail stores in the United States are (known to be) treated with irradiation.

vii. Another method for overcoming microbial contamination is to process the herbs and spices into their essential oils and oleoresins.

Nigerian ginger has been found to be of superior quality that is good and suitable for both productions of ginger oleoresins and essential oil. Due to the lack of ginger processing facilities within the country the farmers have to sell their produce in the fresh form and traditionally dried form at low prices. This is of
inferior quality than the mechanically processed one. Processing facilities within the country can make Nigerian ginger compete in the world market with added value. Moreover, since ginger began to be used in processed products, it has become necessary to ensure consistent taste and flavour for the purposes of standardization. If is for some of these reasons that there has been a movement away from the ground spices generally towards the use of the processed forms of ginger namely; essential oil and oleoresin.

1.6 Post-Production Operations

1.6.1 Harvest

The time of harvest after planting depends on the end-use. For fresh products and preserves, one should harvest rhizomes while they are still tender, low in pungency and fiber content, therefore before they are fully mature. Harvest for dried spices and oil is best at full maturity, when the leaves turn yellow; leaving the rhizomes in the ground past that stage may reduce pungency and oil content, and increase the fiber content.

Maximum oil and oleoresin contents are between 150 and 170 days after planting. In Hawaii, gingerol, the pungent constituent of ginger, increased over time in rhizomes of 'Hawaiian' cultivar as measured on a fresh-weight basis, while it reached a peak 16 weeks after planting on a dry-weight basis, decreased and increased again to reach a second peak at 24 weeks. Likewise, the maximum oleoresin content was reached after 28 weeks on a fresh weight basis. Time from planting to maturity may be highly affected by the type of soil in which ginger is grown.

In summary, the best harvest time for each end-use is:

For fresh consumption: 5 months
For preserved ginger: 5-7 months

For dried ginger: 8-9 months, when leaves start yellowing

For essential oil production: 8-9 months

In some countries, harvest is fully mechanized using special equipment; the crop must be planted in such way that interspacing between rows is adapted to equipment. Care should always be taken to assure integrity of the rhizomes during harvest and postharvest handling.

1.6.2 Washing and drying

Fresh rhizomes should be washed, and cleaned from debris, shoots and roots. When available, pressure washing is preferred as it is more efficient and tends to reduce the microbial load. Traditionally, rhizomes are killed by a 10 min. immersion in boiling water, which also inactivates enzymatic processes, then sun-dried.

Another method is to scrape, peel, or slice rhizomes prior to drying. Peeling or scraping is advised for reducing drying time, thus minimizing mold growth and fermentation. However, while this process decreases the fiber content by removing the outside corky skin, it also tends to remove some of the oils constituents, as they are more concentrated in the peel, and therefore reduces some of the pungency. The peeled rhizomes may be bleached to improve appearance.

After peeling and washing, rhizomes are first soaked in water for 2 to 3 hours, then steeped in a solution of 1.5 to 2.0% lime (calcium oxide) for 6 hours, then drained and sun-dried. This procedure is used when a light bright color is desired.

The Indian Spice Board recommends the following sequence for preparing dry spices:
Soaking in water overnight to loosen the soil, peeling/scraping with pointed-end bamboo splinters, washing off the residual peel, sun drying for one week, soaking in 2% lime for 6 hours, and final drying (www.indianspices.com/html/s1926pac.htm).

Drying should be done to 8-10% moisture, and should not exceed 12%. Expected weight loss during drying is 60-70%. Cleaning and drying procedures should be done as fast as possible after harvest to ensure minimum loss from microbial contamination, mold growth and fermentation. Mechanical washers, slicers, and solar or hot air driers may help minimize contamination from dust during post harvest handling operations.

Sun-drying peeled ginger takes 7 to 9 days to reach a moisture content of 7.8% to 8.8%. If the ginger is sliced, it takes only 5 to 6 hours by using a cross-flow drier, while it takes 16 to 18 hours to dry scraped whole ginger using the same equipment and conditions. Mechanical drying will ensure a more homogenous and cleaner product. When drying with hot air, care should be taken to adjust air flow and temperature. Drying should not exceed the critical temperature of 60 ºC to avoid flesh darkening and discoloration.

Specific equipment is suggested for optimum cleaning of the dried rhizomes. An air screen separator will help remove dead insects, excreta and extraneous matter, while a rotary knife cutter with a screen separator will help remove residual insects and other extraneous matter.

The following terms are used to describe the various forms of dried rhizome.

- **Peeled, scraped, uncoated**: whole rhizome with the corky skin removed
- **Rough scraped**: whole rhizome with the skin partially removed
- **Unpeeled or coated**: whole rhizome with skin intact
- **Black ginger**: whole rhizomes scalded before being scraped and dried
**Bleached**: whole rhizome treated with lime or diluted sulfuric acid

**Splits and slices**: unpeeled rhizomes, split or sliced

**Ratoons**: second growth rhizomes, small, dark and very fibrous.

**Quality specifications** are imposed by the importing country, and pertain to cleanliness specifications rather than quality of the spice as stated in table 1.

Table 1: ASTA Cleanliness Specifications for Ginger

<table>
<thead>
<tr>
<th>Extraneous Matter</th>
<th>Whole insects, dead</th>
<th>Excreta, Mammalian</th>
<th>Excreta, Other</th>
<th>Mold</th>
<th>Insect Defiled/Infested</th>
<th>Extraneous Foreign Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>by count</td>
<td>by mg/kg</td>
<td>by mg/kg</td>
<td>No more than 3%</td>
<td></td>
<td>% by weight</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6.6</td>
<td>6.6</td>
<td>moldy</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Extraneous matter includes but is not restricted to: stones, dirt, wire, string, stems, sticks, non toxic foreign seeds, excreta, manure, and animal contamination.

Proper care must be taken to meet minimum requirements otherwise a lot may be rejected and need further cleaning and/or disinfection with ethylene oxide or irradiation.

**1.6.3 Packaging**

Dry slices or powder are packaged in Kraft multi-wall laminated bags. Some laminates may be better than others due to film permeability. Whichever film is used, storage in a cool and dry environment is crucial for dry spices.

**1.6.4 Storage**

Dried rhizomes, slices, or splits should be stored in a cool environment (10-15°C). When stored at room temperature (23-26 °C), losses of up to 20% oleoresin (dry weight) were observed on dry ginger after 3 months, and the content of gingerol decreased. It is therefore recommended to extract or distill dried ginger rapidly, if cold storage is not available, when oil or oleoresin is the final product. The importance of a dry storage for dried ginger destined for
distillation can only be emphasized because additionally, mycotoxins from mold may be co-distilled with the essential oil. Mold and bacteria developing on dried rhizomes may be efficiently controlled with gamma-irradiation at doses of 5 to 10 kGy, with minor changes in the quality of ginger oil. Ethylene oxide is also used as a fumigation treatment on spices. The U.S. Environmental Protection Agency (EPA) has a maximum tolerance residue for ethylene oxide of 50 ppm on spices. Both disinfection by irradiation and ethylene oxide treatments require specially built and highly secured facilities.

Alternatives to irradiation or synthetic chemicals were investigated by the Indian Institute of Spices Research. They found that leaf powder of Glycosmis pentaphylla and Azadirachta indica added to dried ginger rhizomes in sealed polyethylene bags were effective at preventing damage from the cigarette beetle (Lasioderma serricorne) (http://www.iisr.org/department/cropprod/hhigh.htm).
SECTION II: THE PROCESSED GINGER PRODUCTS

2.0 The major processed forms of ginger are ginger oleoresin and ginger oil. The current stress on a healthful diet with reduced sodium, fat and sugar, has helped generate an escalating interest in spices as a source of novel flavors. The Food Industry across the globe is turning more and more to spice oils and oleoresins to create newer varieties of food.

2.1 GINGER OLEORESINS

Oleoresins are extracts from herbs or spices used as flavoring and coloring in food products and pharmaceutical compositions. Ginger oleoresin is a dark brown viscous liquid, with a volatile oil content of 15%. They originated in the 1930’s when the oleoresins of black pepper and ginger were developed. These original oleoresins were produced by dissolving ground spice with a solvent, removing the solvent under vacuum and disposing of the waste materials. The spice oleoresins are actually the concentrated liquid from the spices that reproduce the character of respective spice fully. Ginger has an average oleoresin content of 5.87% per weight of whole (Kannan and Madhusoodanan, 2007). These first oleoresins were heavy masses of the volatile and non-volatile portion of spices. As extraction technology improved, product quality and demand increased. Oleoresins have numerous advantages over whole or ground spices. They can be customized to a specific food product’s requirements for invisibility, solubility and dispensability. Other advantages include instant flavour release, standardized flavour, and aroma to meet precise specifications, uniform dispersion in the product, and easy handling and storage.
Oleoresins are also free from enzymes, tannins and contain natural antioxidants. They do not contribute color and moisture significantly to the final product. The losses from volatilization of essential oil are minimized due to the presence of resins.

They are free from bacteria, filth and other contaminants. They have long shelf life like under normal and semi-adverse conditions. They require less warehouse space required to store equivalent amount of natural spice flavour. Furthermore, they require less time in cleanup Spartans because liquid oleoresin does not leave particulate matter.

The demand for spice oils and oleoresins is increasing day by day, as more and more spicy snacks are being developed and introduced by fast food chains with standardized flavors.

2.2 METHODS OF OLEORESIN EXTRACTION
Traditionally, the essential oil/oleoresin from rhizome is extracted using solvent extraction and steam distillation techniques by employing high temperatures. Several studies have indicated that high temperature reduces the antioxidant activity and total phenolic contents in the extracts. Recently, supercritical carbon dioxide (SC-CO$_2$) extraction is gaining much attention over thermal extraction to produce essential oils of pharmaceutical importance (Said et al. 2014). Because of its unique properties of separating natural products at room temperature and at a reasonable price, the problem of thermal degradation of antioxidants, polyphenols and other volatile compounds can be reduced (Said et al. 2014). The method also has the ability to produce solvent-free products. According to the SC-CO$_2$ extraction is the best method to extract gingerol constituents from fresh ginger with respect to the solvent extraction. In addition, carbon dioxide is generally recognized as safe for use in food applications. However, ultrasound-assisted extraction is a novel method to effectively extract chemical constituents
from plant materials. Many investigations have reported that the use of ultrasound treatment prior to supercritical extraction process enhances both extraction rate and yield. In recent years, ultrasound-assisted extraction method was also successfully applied in the extraction of natural compounds from garlic, olives and coconut shell powder (Rodrigues et al. 2008).

2.2.1 Solvent Extraction Process

Oleoresins are obtained from spices by extraction with a non-aqueous solvent followed by removal of the solvent by evaporation. To start with various raw spices are cleaned and then ground to the required mesh size. Then extraction is undertaken with the help of proper solvent. Solvents that can be used are hexane, acetone, ethylene dichloride, or alcohol. Extraction is done by percolation of the solvents at room temperature through a bed of ground spice packed in a SS percolator. Then the dark viscous extract containing not less than 10% of total soluble solids are drawn off and distilled under reduced pressure to remove the excess of solvent. The essential oil is obtained by steam distillation. The main steps required to produce oleoresins with solvents, are indicated in the flow chart shown in figure 3.
2.2.2 Supercritical Fluid Extraction Process

A supercritical fluid is any substance at a temperature and pressure above its critical point, where distinct liquid and gas phases do not exist. In addition, close to the critical point, small changes in pressure or temperature result in large
changes in density, allowing many properties of a supercritical fluid to be "fine-tuned".

The advantages of supercritical fluid extraction (compared with liquid extraction) are that it is relatively rapid because of the low viscosities and high diffusivities associated with supercritical fluids. The extraction can be selective to some extent by controlling the density of the medium and the extracted material is easily recovered by simply depressurizing, allowing the supercritical fluid to return to gas phase and evaporate leaving no or little solvent residues.

Carbon dioxide is the most common supercritical solvent. The use of supercritical fluids is essentially limited to supercritical carbon dioxide (SCF\textsubscript{CO}_2) extraction since carbon dioxide has the advantages of being inexpensive and nontoxic and because its critical point is easily reached.

2.2.3 Process Description

According to Spiro and Kandiah (1990) model. Ginger root is charged to T-101, as described in Fig. 4 the extraction vessel. Supercritical CO\textsubscript{2} is then fed from the holding tank, TK-101, to the extractor. The supercritical CO\textsubscript{2} is then passed through the extraction vessel for a total of six hours.
At the end of the six hours, 95% of the 6-gingerol, which is assumed to make up 30% of the ginger oleoresin, has been removed from the ginger root. The \( \text{CO}_2 \) and extracted ginger oleoresin leave the extractor and enter E-101, the pre-heater, where the mixture is heated using low-pressure steam. The pressure of the
mixture is then throttled to 65 bar, causing the supercritical CO\(_2\) to become a gas. The two-phase mixture then enters the flash vessel, V-101, where essentially all of the liquid oleoresin exits from the bottom of the flash vessel. Essentially all of the CO\(_2\) exits the top of the flash vessel and then enters C-101 and E-102, where it is compressed and cooled back to supercritical pressure and temperature. The recycled CO\(_2\) is then sent back to TK-101.

After the extraction, the CO\(_2\) and extracted ginger oleoresin enter a pre-heater and then a throttling valve. It is necessary to heat the mixture before entering the valve to keep the oleoresin above its freezing point of 31°C upon the reduction in pressure.

The process is operated such that the entire amount of CO\(_2\) in the holding tank is circulated through the process only once over the six-hour extraction period. Once a given amount of CO\(_2\) has passed through all the pieces of equipment, it is sent back to the storage tank where it is accumulated for extraction of the next batch of ginger root. The process is then shut down for two hours while the spent ginger is removed from the extractor and a new batch of ginger root is charged to the extractor.

### 2.2.4 Environmental Significance

Replacement of organic solvents such as hexane, ethyl acetate, and chlorinated hydrocarbons with a benign solvent such as supercritical CO\(_2\) is also considered desirable from an environmental standpoint. It is:

i. environmentally friendly extraction process

ii. Safe substitute for organic solvents

iii. Volatile organic compound (VOC) emissions eliminated

### 2.2.5 Steam Distillation Process
Different processing methods are required to extract essential oils from different plants. Most oils are extracted using steam distillation, during which the plant material is permeated with steam. As the plant tissues break down, the essential oils and water vapor are released, then collected and cooled. The volatile essential oil condenses, separates and is easily isolated. In this process the steam is prepared in a separate chamber and piped into the tank. This is more expensive than the other methods. This is especially good for plant materials with high boiling point oils. In this method the temperature and pressure can be increased for certain oils. The rate of distillation and yield of oil are high and the quality of the oil is good.

The quality of an oleoresin is typically evaluated on the basis of: -

1. Presence of the active ingredients in the desired levels
2. The bite giving resin portion containing a combination of alkaloids, gums, pigments, etc.
3. The aroma giving volatile/essential oil component
4. The comparison of the flavour/aroma profile of the oleoresin in comparison with the natural spice in application.
5. The ease of use in terms of viscosity, dissolvability, blending, etc.
6. The consistency of flavour, color, viscosity over repeated batches.
7. The acceptability of the extraction solvent used and mineral residual levels present thereof. Acetone, hexane, alcohols, methylene chloride and CO\textsubscript{2} are commonly used solvents. However, chlorinated solvents are gradually getting phased out in most part of the world due to concerns about their carcinogenicity.
2.3 Value Additions

2.3.1 Standardization of Oleoresins

Standardization is necessary when essential oils are added to the oleoresins to increase or reinforce the flavour and increase the “test” of the spice. Because these standard oleoresins are blended with essential oils, they are functional spice but not true representation of the plant material. Standardized oleoresins maintain a consistent percentage of essential oil. Each manufacturer standardizes its oleoresin so that these spice extractives produce the same flavor from batch to batch and from year to year. This process of standardization reduces the difference caused by varying quality and sources of spice crops.

2.3.2 Dilution

The oleoresin contains the aroma and flavour of the spice in a concentrated viscous liquid or semi-solid form. Due to this high concentration, oleoresins cannot be incorporated into food products unless they are diluted. Dilution could be achieved by dispersing the oleoresin on a dry cannier such as salt dextrose sugar or starch to produce a dry soluble spice. It could also be dispersed to produce fat based soluble spice or by emulsifying the oleoresin with gum acacia or by dissolving it in alcohol or another appropriate solvent to yield a liquid soluble spice.

2.4 Ultrasound Treatment on Dried Ginger Powder

An ultrasound treatment on the raw material creates novel and interesting methodologies, which are often complementary to conventional extraction methods.
The ultrasound pretreatment was given in flat bottom flask at 40°C for 60 min. The temperature was maintained using a water bath temperature controller. After completion of the ultrasound treatment, the material is placed into the extractor for SCFCO₂ extraction. The extraction is then carried out in SCFCO₂ unit at a pressure of 20 and 25 MPa and temperature of 32 and 35°C, respectively.
SECTION III: EXTRACTION PLANTS DETAILS AND REQUIREMENTS.

3.0 EXTRACTION PLANTS DETAILS AND REQUIREMENTS.

3.1 RAW MATERIALS

The major raw material for the factory is ginger. It constitutes one of the chemistry that can be found in natural herbs, which are essential to the human body. The Nigerian Ginger is one of the best in the world. If properly processed, e.g. oleoresin, it can be used in the pharmaceutical industries in making drugs and can also be used in the cosmetics and food industries. Ginger is a seasonal crop, therefore to ensure continuous production the commodity has to be stockpiled during the harvest season.

3.2 ETHANOL

The solvent used for the extraction of oleoresin is ethanol with a concentration of between 90 - 95%.

3.3 Equipments Manufacturers of Ginger Oleoresin

Some of the machinery suppliers’ including their contact details are;

(i) Flour Tech Engineers Pvt Ltd, 16/5, Mathura Road, Faridabad 121 002
    Tel. No.: 2263017, 2291556, Fax: 2291556

(ii) Flavourite Foods & Services Pvt. Ltd, 208 Manas Bhavan, 11, RNT Marg,
    Indore 452 008 Tel. No. : 2527644, 5046509, Fax: 5040953

(iii) FMC Technologies Hong Kong Ltd, 2 Bhuvaneshwar Housing
    Soc, Pashan Road, Pune 411 008 Tel. No. : 5893700, Fax: 5893701
(vi) SS Engineering, B-24, Khanpur Extension, New Delhi 110 062, Ph: 26081475, 9810217935

(v) Sahyog Steel Fabrication, 28 Bhojrajpara, Gondal 360 311 Tel. No.: 224075, Fax: 231375

(vi) Cowel Can Ltd, Industrial area, Post Barotiwala, Dist. Solan (HP)

(vii) Deven Supercriticals Pvt. Ltd. Mumbai, India specialize in design, manufacture and supply of Supercritical fluid CO2 oleoresin extraction equipments such as:

- Extractors / Reactors (E / R)
- Separators (S)
- CO2 Tank (T)
- Condenser (CN)
- Pre-cooler (PC)
- Evaporator (EV)
- Pre-heater (PH)
- CO2 Pump (P1)
- Entrainer Pump (P2)

3.3 Machinery

The installed capacity of the plant is 1metric ton of split-dried ginger per hour yielding between 40 to 50kg of oleoresin. The equipment is designed to operate continuously for 24hrs, this means operating 3shifts of 8hrs per day This would require the following set of equipments:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginger spray washing machine</td>
<td>1</td>
</tr>
<tr>
<td>Brush type ginger Peeling and</td>
<td>1</td>
</tr>
<tr>
<td>Equipment</td>
<td>Quantity</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>washing Machine</td>
<td></td>
</tr>
<tr>
<td>Ginger slicing machine</td>
<td></td>
</tr>
<tr>
<td>Ginger powder crushing machine</td>
<td>1</td>
</tr>
<tr>
<td>Dryer</td>
<td>48trays</td>
</tr>
<tr>
<td>Weighing-scales, sealing machine, etc</td>
<td>1</td>
</tr>
<tr>
<td>Vacuum packing machine</td>
<td>1</td>
</tr>
</tbody>
</table>

### 3.4 Miscellaneous Assets

Certain other assets like furniture and fixtures, storage racks, knives and cutters, plastic tubs, packing tables etc. shall be required for which an amount must be proposed.

#### 3.4.1 Utilities

Power requirement shall be 10HP whereas water requirement will be 400-500 litres every day.

#### 3.4.2 Major Infrastructural facilities

The following infrastructures are recommended to be provided in the common processing centre.

- Cleaning, grading, drying, processing, powdering, distillation/extraction, sterilization, packing and quality testing
- Scientific storage
- Uninterrupted and adequate power and water supply
- Act as a facilitator for technology transfer/high end value addition to the entrepreneurs
- Training center for educating good agricultural practice and quality requirements of spices to farmers, traders, processors and exporters.

### 3.5 Manpower requirements

The factory is meant to be made up of both technical and non-technical staff including expatriates as illustrated in the table below.

**Table 1; Manpower and estimated worth**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Nos.</th>
<th>Monthly Salary (#)</th>
<th>Total (#)</th>
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</thead>
<tbody>
<tr>
<td>Manager/Accountant</td>
<td>1</td>
<td>50,000</td>
<td>50,000</td>
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<tr>
<td>Agronomist(Technical Officer)</td>
<td>1</td>
<td>45,000</td>
<td>45,000</td>
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<tr>
<td>Purchase Officer</td>
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<tr>
<td>Marketing Officer</td>
<td>1</td>
<td>35,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Process Engineer/Quality Control Officer</td>
<td>1</td>
<td>35,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Factory worker</td>
<td>1</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>225,000</strong></td>
</tr>
</tbody>
</table>

### 3.6 Local Agro-Processing Companies (Ginger Processing)

i. Kachia Food Company Limited, Kaduna, Nigeria.

ii. Belphins Nig. Ltd., Kafanchan, Kaduna State.
SECTION IV: MARKETING

4.0 MARKETING

4.1 Processed ginger trade is a closed trade and the following should be noted:

- Ginger processing to the right specification is a very skilled business. Improper extraction may lead to a loss of the desired principles thus ruining the product for commercial exploitation.

- The bulk of the demand for processed ginger from the food industry is for dispersed spice extract. It was for the reasons that it was recommended that for the Nigerian plant, the straight (un-dispersed) oleoresin extract should be produced, and that this should be marketed through existing concerns in the importing countries such as United States, United Kingdom, Saudi Arabia, Morocco, Japan, Federal Republic of Germany, Yemen, and Canada. This was considered the best course to follow since firms in the importing countries are more familiar with the requirements of the market, are in a better position to meet individual specifications, provide technical know-how, and after sales services more effectively.

4.2 QUALITY CONTROL

Physical examination of the product is undertaken to determine its appearance, odor, and taste. It is also examined for extraneous matter. After the subjective tests of quality assessment are completed, objective physiochemical tests are undertaken. Microbiological contamination poses one of the more serious quality problems, and fumigation and sterilization procedures have been developed to control it. Problems exist, however, in removing the sterilizing agent and the possibility of chemical changes occurring during sterilization.
4.3 LAND REQUIRED FOR OLEORESIN PLANT INSTALLATION

The land space for ginger processing factory should be able to accommodate the main factory building, raw and finished product warehouse, administrative block, power house and boiler room. All the structures can be set up in a 4.5 acres of land; this will also accommodate future expansion.

4.4 PRICE VARIATION OF OLEORESIN

Price list of Oleoresin as published by www.alternativescentral/pricelist. The list indicated Oleoresin primary spice, its origin and price value

**BLACK PEPPER OLEORESIN** *(Piper nigrum)*

Origin: India

1 oz. $13.00  2 oz. $24.00  4 oz. $45.00  8 oz. $86.00  1 lb. $164.00

5 lbs. $790.50  10 lbs. $1498.50  25 lbs. $3688.00

**CAPSICUM 250K SHU OLEORESIN**

(Oleo-Capsicum w/Veg Oil)

Origin: United States

1 oz. $2.50  2 oz. $4.75  4 oz. $9.00  8 oz. $17.50  1 lb. $34.00

$159.00  10 lbs. $306.50  25 lbs. $729.00

**CLOVE BUD OLEORESIN**

*(Eugenia caryophyllata)*

Origin: India

1 oz. $3.50  2 oz. $6.75  4 oz. $13.00  8 oz. $25.00  1 lb. $49.00

$224.50  10 lbs. $429.00  25 lbs. $1039.50
GINGER OLEORESIN (*Zingiber officinale*)

Origin: India

1 oz. $10.00  2 oz. $18.50  4 oz. $35.00  8 oz. $65.00  1lb. $122.00

5 lbs. $509.50  10 lbs. $986.50  25 lbs. $2388.50

PAPRIKA 100,000 C. V. OLEORESIN (*Capsicum annuum*)

Origin: United States

1 oz. $4.75  2 oz. $9.00  4 oz. $17.00  8 oz. $33.00  1lb. $65.00

lbs. $629.50  10 lbs. $1229.00  25 lbs. $2949.50

TUMERIC OLEORESIN

(*Curcuma longa*)

Origin: United States

1 oz. $3.50  2 oz. $6.75  4 oz. $13.00  8 oz. $25.00  1lb. $49.00

5 lbs. $224.50  10 lbs. $429.00  25 lbs. $1039.50

BENZOIN LIQUID RESIN

(*Styrax tonkinesis*)

Origin: Indonesia

1 oz. $7.50  2 oz. $14.00  4 oz. $25.00  8 oz. $45.00  1lb. $80.00

5 lbs. $374.50  10 lbs. $698.00  25 lbs. $1689.50
## 4.5 World Import and Expt ort pricing trend of Ginger Oleoresin

### Table 2. Import export price of ginger produce

<table>
<thead>
<tr>
<th>Date</th>
<th>HS Code</th>
<th>Description</th>
<th>Origin</th>
<th>Port of Discharge</th>
<th>Qty(kgs)</th>
<th>Value (INR)</th>
<th>Per Unit (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct/27/2016</td>
<td>33019012</td>
<td>OLEORESIN GINGER (RE IMP) EXP SB:8601847/30.06.16</td>
<td>India</td>
<td>Cochin Sea</td>
<td>510</td>
<td>1,228,855</td>
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<td>Oct/20/2016</td>
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<td>GINGER OLEORESIN FDO (ESSENTIAL OIL)</td>
<td>United States</td>
<td>Bombay Air Cargo</td>
<td>45</td>
<td>480,871</td>
<td>10,601</td>
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<td>Oct/06/2016</td>
<td>33019012</td>
<td>GINGER OLEORESIN-BATCH NO:710985USED FOR ORAL CARE COMPOUNDING ENDUSE TOOTHPASTE</td>
<td>United Kingdom</td>
<td>Chennai Sea</td>
<td>180</td>
<td>662,526</td>
<td>3,681</td>
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<tr>
<td>Aug/04/2016</td>
<td>33019012</td>
<td>GINGER OLEORESIN FDO (ESSENTIAL OIL)</td>
<td>United States</td>
<td>Bombay Air Cargo</td>
<td>23</td>
<td>239,471</td>
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<td>Aug/03/2016</td>
<td>33012990</td>
<td>RM1040 - GINGER INDO OLEORESIN 25 OIL</td>
<td>Australia</td>
<td>Bangalore Air Cargo</td>
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<td>113</td>
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<tr>
<td>Date</td>
<td>P/NO.</td>
<td>Item Description</td>
<td>Supplier Country</td>
<td>Port of Delivery</td>
<td>Quantity</td>
<td>Total Value</td>
<td>Unit Price</td>
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<tr>
<td>Aug/03/2016</td>
<td>33012990</td>
<td>RM1940 - GINGER OLEORESIN - NIGERIAN</td>
<td>Australia</td>
<td>Bangalore Air Cargo</td>
<td>0</td>
<td>270</td>
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<tr>
<td>Jul/11/2016</td>
<td>33019012</td>
<td>GINGER OLEORESIN - NIGERIAN-BATCH NO:710985(USED FOR ORAL CARE COMPOUNDING ENDUSE TOOTHPASTE)</td>
<td>United Kingdom</td>
<td>Chennai Sea</td>
<td>180</td>
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<td>3,595</td>
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<tr>
<td>Jun/20/2016</td>
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<td>DRIED GINGER (DEEC FOR EXPORT OF OLEORESIN GINGER)</td>
<td>Nigeria</td>
<td>Cochin Sea</td>
<td>43,889</td>
<td>5,677,213</td>
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<tr>
<td>Jun/07/2016</td>
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<td>GINGER OLEORESIN(IN10926)(FOOD FLAVOURING MATERIALS)(BATCH 709585)</td>
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<td>Cochin</td>
<td>0</td>
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<td>DRIED GINGER (DEEC FOR EXTRACTION)</td>
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<td>DRIED GINGER (DEEC FOR EXTRACTION AND EXPORT OF OLEORESIN)</td>
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<td>22,670</td>
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<td>5,595,749</td>
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<td>110,000</td>
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<td>DRIED GINGER( DEEC FOR EXPORT OF OLEORESIN GINGER)</td>
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<td>109,068</td>
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<td>OLEORESIN GINGER (RE-IMPORT CARGO)EXPORTED VIDE SB NO. 6826955/01-04-2016 INV:1510055634/31.03.2016</td>
<td>India</td>
<td>Cochin</td>
<td>20</td>
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<td>108,769</td>
<td>14,331,354</td>
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<td>Cochin Sea</td>
<td>107,563</td>
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<td>Date</td>
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<tr>
<td>Feb/17/2016</td>
<td>33019090</td>
<td>GINGER OLEORESIN FDO</td>
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<td>Bombay</td>
<td>34</td>
<td>299,285</td>
<td>8,797</td>
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Source: ZAUBA, (2017)
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Zauba Technologies and Data Services Private Ltd. (2016); www.zauba.com, www.alternativescentral/pricelist