DEVELOPMENT OF GMP AND HACCP PROTOCOL FOR PEPPER INDUSTRY

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PROJECT REPORT

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2009

DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF GMP AND HACCP PROTOCOL FOR PEPPER INDUSTRY"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Place: Tavanur

Date :

Pritty. S. Babu

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Tina Ann Abraham

CERTIFICATE

Certified that this project report, entitled, **“DEVELOPMENT OF GMP AND HACCP PROTOCOL FOR PEPPER INDUSTRY”** is a record of project work done jointly by Pritty. S. Babu, Sarathjith. M. C and Tina Ann Abraham under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, associateship or other similar title of any other University or Society.

Place: Tavanur

Date :

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Pritty. S. Babu

Sarathjith. M. C

Tina Ann Abraham

Dedicated to our loving
Parents

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SYMBOLS AND ABBREVIATIONS

&	and
^{o}C	degree Celsius
≥	greater than or equal to
″	inches
<	less than
µ	micron
/	per
%	percentage
ac	alternating current
AD	Anno Domini
ATA	Alimentary Toxic Aleukia
AOAC	Associates of Official Analytical Chemists
BIS	Bureau of Indian Standards
CCPs	Critical Control Points
cfu	Colony Forming Unit
cGMP	Current Good Manufacturing Practices
COFFS	Canadian On Farm Food Safety
end.	endocarp
epi.	epicarp
et al.	and other people
etc.	etcetera

FAO	Food and Agricultural Organization
Fig.	Figure
ft	feet
g	gram
GAP	Good Agricultural Practice
GC	Gas Chromatography
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Point
hrs	hours
hy.	hypoderm
ICM	Integrated Crop Management
i.e.	that is
IPM	Integrated Pest Management
J	journal
Kg	Kilogram
KW	Kilo Watt
LHA	Local Health Authority
LPG	Liquefied Petroleum Gas
M.C	Moisture content
mes ^{1}	outer mesocarp
mes ^{2}	middle mesocarp
mes ^{3}	inner mesocarp
mes ^{4}	porous cells in one or two rows

ml	millilitre
Mt	Metric tones
Nm	Nano meter
no.	number
pc	pericarp
(P)Ltd	Private Limited
ppm	parts per million
Ps	perisperm
res	oleoresin cells
rpm	revolutions per minute
S	spermoderm
Spp.	Species
SSOP	Sanitation Standard Operating Procedures
t	tones
TPC	Total Plate Count
UN	United Nations
UV	Ultra Violet
Via	through
Viz	namely
wb	Wet basis
WSSS	Wayanad Social Service Society

INTRODUCTION

CHAPTER I

INTRODUCTION

‘Spice’ can be defined as the dry parts of a plant, such as roots, leaves and seeds, which impart to food a certain flavour and pungent stimuli. (Kenji & Takemasa, 1998) Spices have a profound influence on the course of human civilization. They permeate our lives from birth to death. In everyday life, spices succor us, cure us, relax us, and excite us. Ancient peoples such as the Egyptian, the Arab and the Roman made extensive uses of spices, not only to add flavour to foods and beverages, but as medicines, disinfectants, incenses, stimulants and even as aphrodisiac agents. No wonder they were sought after in the same manner as gold and precious metals.

Asia is known as the ‘Land of Spices’ as it is the place of origin, production, consumption and export of most spices. India's share of world trade of spices is forecast to increase. India’s share in the world spice market is estimated as 46 per cent by volume and 26 per cent by value (Peter *et al.*, 2006). They are Black pepper (Piper nigrum), Cardamom (*Elettaria cardamomum*), Cinnamomum (*Cinnamomum camphora)*, Chili pepper (*Capsicum annuum*), Clove *(Syzygium aromaticum)*, Coriander *(Coriandrum sativum)*, Cumin *(Cuminum cyminum)*, Garlic *(Allium sativum)*, Ginger *(Zingiber officinale)*, Turmeric *(Curcuma longa)*, Vanilla *(Vanilla planifolium)*, Nutmeg and Mace *(Myristica fragrans.* India plays a significant role on the pepper market both as supplier and consumer. India produces about 64 varieties of spices and is the world's largest producer and exporter, accounting for about 20 percent of world consumption. (Menon, 1998)

Among the major spices black pepper which was originated in Kerala has been one of the most ancient commodities of the spice trade. From Kerala here it spread to the rest of South and Southeast Asia where it became an important spice plant. It was eagerly sought by Europeans. Pepper was termed as *‘King of Spices’* for its importance in uses of human beings. Pepper was an essential seasoning in Indian food and there are numerous references to it in Tamil literature dating between the 1^{st} to 4^{th} centuries AD. During

2005-'06, 16,700t of black pepper products were exported to various countries accounting for 6.0 % of export earnings among spices The growers and traders are liked to call it as *'Black Gold'* for its high market value. (Sasikumar et al., 2008)

Dried fruits of pepper are usually known as peppercorns. Depending on harvest time and processing, peppercorns can be black, white, green and red (actually, reddish brown). The traditional types are black and white; dried green peppercorns are a more recent innovation, but are now rather common in Western countries. Red peppercorns, however, are still a very rare commodity. Peppercorns are also available pickled in brine or vinegar. This is the traditional form of preservgreen peppercorns, but in recent years, preserved red peppercorns have become increasingly popular. (Purseglove *et al.*, 1981)

Generally around 75% of production of pepper is exported. The consumption in producing countries except in India is insignificant. India consumes about 40,000 Mt of pepper (Sadanandan, 2000). World exports of pepper also have shown increasing trend but not in proportion with the increase in production. The supply position has increased considerably whereas the demand remained static or achieved only nominal increase. As such the gap between the supply and demand has widened. As a result, the price has declined steeply in the recent years. Usually when there is an over supply, price will decrease, then the growers loose their interest, which will result in decrease in production. Then short supply position takes place resulting in increase in price and more production.

The quality of a product may be defined as "its ability to fulfill the customer's needs and expectations". Quality can also be defined as "that which makes a thing what it is; nature, character, kind, property, status, grade of goodness and excellence." It is necessary to exercise a strict check and control over the qualities of goods offered for sale. The parameters of quality are the grade, standards and specifications laid down by the government or expert bodies constituted for the purpose. (Andrew, W.S., 2006)

Quality of spices is assessed by its intrinsic as well as extrinsic characters. The former consists of chemical quality, i.e. the retention of chemical principles like volatile oil, alkaloids and oleoresins while the latter emphasizes physical quality. These include appearance, texture, shape, presence or absence of unwanted things, colour, etc. In addition, certain health requirements are also implemented as export quality standard viz. pesticide residue aflatoxin, heavy metals, sulphur dioxide, solvent residues and microbiological quality. However, physico-chemical quality remains the ultimate attribute, while considering export requirement of spices as these properties delineate its grade in the market. These qualities vary unpredictably. The quality of the food product can be maintained with the help of proper food safety and management systems like Good Manufacturing Practices (GMP), Good Agricultural Practices (GAP), and Hazard Analysis and Critical Control Points (HACCP).

Good Manufacturing Practice or GMP (also referred to as 'cGMP' or 'current Good Manufacturing Practice') is a term that is recognized worldwide for the control and management of manufacturing and quality control testing of foods and pharmaceutical products. GMP takes the holistic approach of regulating the manufacturing and laboratory testing environment itself. An extremely important part of GMP is documentation of every aspect of the process, activities, and operations involved with food processing. (http:// supplements quality.com)

The high quality and healthy food become more important and consumers have concerns about control of food production and demand information along the food chain. Good agricultural practices (GAP) is based on the principles of risk prevention, risk analysis, sustainable agriculture by means of Integrated Pest Management (IPM) and Integrated Crop Management (ICM), using existing technologies for the continuous improvement of farming systems. The GAP is the utmost important for protection of consumer health. It requires ensuring safety throughout the food chain and it must be compulsory transparent not only from the table but also upstream.

HACCP is the internationally recognized and recommended approach to ensure food safety. It is an analytical tool that enables management to introduce and maintain a cost-effective, ongoing food safety program. HACCP involves the systematic assessment of the steps involved in a food manufacturing operation and the identification of those steps that are critical to the safety of the product. The analysis allows management to concentrate resources into those manufacturing steps that critically affect product safety.

A Hazard analysis will produce a list of Critical Control Points (CCPs), together with control parameters (with critical limits), monitoring procedures and corrective actions for each CCP. For continuing safety and effectiveness of the plan, records must be kept of each analysis and the efficacy of the study must be verified on a regular basis, and when aspects of the operation change.

HACCP is designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption. HACCP is applicable to the identification of microbiological, chemical, and physical hazards affecting product safety. Food safety systems based on the HACCP principles have been successfully applied in food processing plants, retail food stores, and food service operations. The seven principles of HACCP have been universally accepted by government agencies, trade associations and the food industry around the world. (American Spice Trade Association, Inc. 2006.)

So, by incorporating aforementioned safety management principles in pepper industry the quality and there by the market value of exported pepper can be made superior. With this background information we have taken up this study 'Development of GMP and HACCP Protocol for Pepper Industry' with the following objectives

I. To conduct gap analysis after visiting spice industries
II. To analyze the existing process line in various industries
III. To standardize the HACCP protocol for pepper industries

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

This chapter deals with a brief review of the crop, its characteristics and the research work carried out by various investigators on development of GMP and HACCP module in various spices industries. Structure and composition of pepper spices have also been reviewed and discussed briefly.

2.0 PEPPER

2.1 Origin

Pepper is a large genus, with over 1000 species, in the family *Piperaceae*, which is a perennial climbing vine or shrub with a smooth woody stem mostly found in hot and moist region of Southern India (Govindarajan, 1977). It is a perennial herbaceous woody climber of 5m or more in height with a bushy columnar appearance. The spikes are borne on the piagiotropic branches opposite to the leaves and are 3 to 15cm long. The fruits or berries are 4 to 7mm in diameter and have a pulpy pericarp and a hard endocarp (Purseglove *et al.*, 1981). Fruits are botanically called drupes but generally called berries. The unripe is green with exocarp turning red when ripe and black on drying.

2.2 Varieties

The varieties under cultivation have been evolved by unconscious selection from natural hybridization and vegetative propagations; thus, they show considerable variation in habitat, size and shape of fruit, and fruiting behavior. More than 75 named-varieties are known to be cultivated in India. They are distinguished by the names of the areas of cultivation. Introductions from one area to another have also taken place, resulting in the same variety being known by different names at different places. The common varieties of pepper grown in India are shown in Table 2.1.

Table 2.1 Important cultivars of black pepper and their features

Cultivar	Fresh mean yield kg/vine	Oleoresin (%)	Piperine (%)	Essential oil (%)	Dry recovery (%)	Features
Aimpirian	4-5	15.0	4.7	2.6	34	Good for higher elevations, good in quality, late maturing
Arakulamunda	2	9.8	4.4	4.7	33	Moderate and regular bearer
Balankotta	1-2	9.3	4.2	5.1	35	Moderate and irregular bearing
Karimunda	2-3	11.0	4.4	4.0	35	High yielder, shade tolerant
Kalluvally	1-2	8.4 -11.8	2.5 -5.4	3.0	35 -38	High dry recovery, drought tolerant
Kottanadan	5	17.8	6.6	2.5	34 -35	High yielding. Drought tolerant
Kuthiravally	3	15.0	6.0	4.5	35	High yield,good quality
Narayakodi	1-2	11.0	5.4	4.0	36	Moderate yield, medium quality
Neelamundi	2	13.9	4.6	3.3	33 -34	Tolerant to *Phytophtora* infection
Vadakkan	3	10.8	4.2	3.2	-	Medium quality and yield

Source: Sasikumar *et al.* (2008)

2.3 Harvesting and yield

First harvest of pepper is done during the third year after planting. Pepper starts flowering even one year after planting. After flowering, it takes about 8 to 9 months for maturity. Generally, harvesting is done when one or two berries in a few spikes turn orange or red. Harvesting in Kerala is usually done from November to February. The maturity desired at harvest for production of various end products is given in Table 2.2.

Table 2.2 Maturity of pepper desired at harvest for different end products

End-Product	Maturity at harvest
White pepper	Fully ripe
Black pepper	Fully mature and nearly ripe
Canned pepper	4 – 5 months after fruit set
Dehydrated green pepper	10-15 days before maturity
Oleoresin	15-20 days before maturity
Oil	15-20 days before maturity
Pepper powder	Fully mature with maximum starch

Source: Govindarajan (1977)

2.4 Structure and composition of pepper berry

A longitudinal section of the corn shows a thin pericarp and spermoderm enclosing single seed. The greater part of the seed consists of a starchy mass around a hollow centre. The embryo is embedded in a small endosperm at the apex of the seed.

Structural details of skin layers and perisperm of black pepper is shown in Fig. 2.1. Seven layers as detailed below are differentiated in the pericarp of pepper (Winton and Winton, 1939).

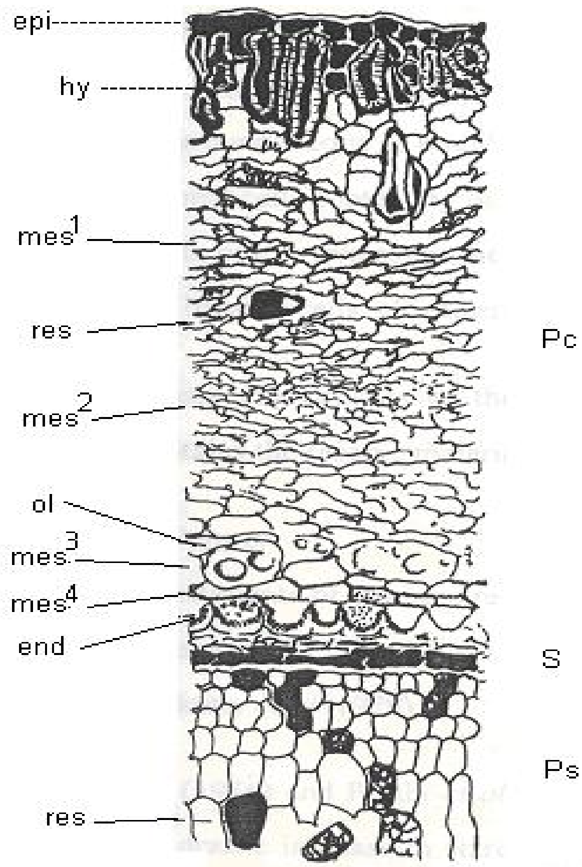


Fig. 2.1 Structural details of skin layers and perisperm of black pepper

1. Epicarp of polygonal cells, dark contents, and stomata (epi).
2. Hypoderm of polygonal cells and a group of radially elongated stone cells(hy.)
3. Outer mesocarp (mes^1) of polygonal cells interspersed with a few oleoresin cells(res.)
4. Fibovascular bundle zone or middle mesocarp (mes^2)
5. Large polygonal cells containing oil (ol) or inner mesocarp(mes^3)
6. Porous cells in one or two rows(mes^4)
7. Endocarp of breaker cells, characteristics of pepper (end).

The pericarp (Pc) contains the epicarp and hypoderm. The spermoderm (S) consists of three layers and the perisperm (Ps), which is peculiar in pepper, and contains the reserve material starch embedded in a cuticular layer.

2.5 Constituents of pepper

The major constituents of pepper are starch, fibre and protein but more significant ones are the piperine and the volatile oil, which contribute the pungency and aroma respectively (Sumathikutty *et al.*, 1979). The white pepper has a higher starch content but lower fibre content compared to black pepper. The major constituents of black pepper and white pepper are given in Table 2.3.

Table 2.3 Constituents of white- and black-pepper

Chemical constituents (%)	Black pepper	White pepper
Moisture	13.0	14.0
Volatile oil (v/w)	4.1	3.8
Piperine	2.3	3.2
Nonvolatile ether extract	12.0	8.2
Oleoresin	9.6	7.2
Starch	40.5	48.0
Crude fibre	14.0	4.0
Ash	7.0	2.0
Acid insoluble ash	1.5	0.6

Source: Thomas *et al.* (1987)

2.6 Quality of Pepper

If a product fulfils the customer's expectations, the customer will be pleased and consider that the product is of acceptable or even high quality. If his or her expectations are not fulfilled, the customer will consider that the product is of low quality. Thus the quality of a product may be defined as "its ability to fulfill the customer's needs and expectations". Quality needs to be defined firstly in terms of parameters or characteristics, which vary from product to product. For example, for a mechanical or electronic product these are performance, reliability, safety and appearance. For pharmaceutical products, parameters such as physical and chemical characteristics, medicinal effect, toxicity, taste and shelf life may be important.

2.6.1 Pepper oil

Lewis *et al.* (1969) reported that the yield of pepper oil varies from 2 to 3.5 per cent and it consists of major monoterpene hydrocarbon (70 to 80 per cent), sesquiterpenes (22 to 30 per cent) and oxygenated compounds. In general, the chief monoterpene hydrocarbon constituents are α-pinene and β-pinene, limonene and sabinene. Sesquiterpene hydrocarbon present is mainly β-caryophyllene. The oxygenated derivatives, which are the chief contributors to aroma, represent only 3 per cent of the total oil.

Richard *et al*. (1971) studied the volatile components of black pepper varieties by Gas Chromatograph (GC) methods. Panniyoor-1 and Narayakodi exhibited low monoterpene hydrocarbon concentrations (55 and 51.5 %, respectively).

Pruthi (1980) has shown that starch content increases during maturation whereas volatile oil decreases and little change was observed in non-volatile ether extract and piperine.

According to Balakrishnan (1992), essential oil represents the total aroma of the parent spice. It does not impart colour to the end product; has uniform flavour quality and is free from enzymes and tannins.

2.6.2 Piperine and oleoresin

Extraction of black pepper with organic solvents provides an oleoresin with exact odour, flavour and pungent principles of the spice. The organoleptic properties of the oleoresin were determined by its volatile oil and piperine content. Pruthi (1970) reported that ultra violet spectroscopy and calorimetric analysis were more accurate methods for piperine estimation. Maximum absorption value was observed at 345 nm in benzene or chloroform solution.

According to Sumathikutty *et al*. (1979), the major constituents of pepper are starch, fibre, and protein; but the significant ones are the piperine and volatile oil, which contribute the pungency and aroma respectively.

Mathai (1981) studied different methods for the estimation of oleoresin and piperine in black pepper. Of the three methods studied, the modified cold percolation method was found to be the most efficient for oleoresin estimation; this was followed by soxhlet distillation. The least efficient was (conventional) cold percolation method. Inspite of the use of a very efficient solvent (ethyl alcohol), the conventional method gave a poor oleoresin yield. The piperine content in the oleoresin of modified cold percolation was very much higher compared to other two methods. This could be due to the complete extraction and also the prevention of loss of the alkaloids during the process of extraction and estimation.

Soubhagya *et al*. (1990) conducted a study on piperine estimation in different solvents by spectrophotometric method. From that study, they concluded that pepper oleoresin samples meant for piperine estimation have to be protected from light immediately after dilution. Since ethylene dichloride and benzene are carcinogenic in nature, other solvents like alcohol, acetone and ethyl acetate can be used for the estimation of piperine.

2.6.3 Adulterants in black and white pepper

Food adulteration and contamination, in general, have serious health implications which, of late, have been receiveing greater public attention. This has necessitated the development of sharper and more precise analytical techniques for the detection and determination of adulterants/contamination in the food testing laboratories all over the world.

Seidman (1962) studied about the determination of the temperature of swelling and conversion to paste of starch with the macro heating stage of Boetius, it was possible to differentiate the starches of black pepper and white pepper from those of long pepper, rice, oats.

Czaja (1962) conducted a study on the adulteration of pepper with palm-kernel meal can readily be detected in preparations cleared with chloral hydrate by the characteristic spotted appearance(illustrated by photomicrographs) shown by the thickened cell walls of the palm-kernel tissues.

Mitra *et al.* (1966) analysed black pepper samples containing different amounts of light berries for ash, acid-insoluble ash and starch. Only the starch content varies with the amount of light pepper present so that the starch concentration could be used to estimate the amount of light pepper present.

2.6.4 Mycotoxins

Toxic secondary metabolites, such as the ergot alkaloids, which are produced by certain moulds, are described as 'mycotoxins', and the diseases they cause are called mycotoxicoses'. The mycotoxicosis latterly known as 'alimentary toxic aleukia' (ATA) produced vomiting, acute inflammation of the alimentary tract, anaemia, circulatory failure and convulsions.

As defined by Pitt (1996) mycotoxins are 'fungal metabolites which when ingested, inhaled or absorbed through the skin cause lowered performance, sickness or death in man or animals, including birds.

Miller (1991) reported that the severe depopulation of Western Europe in the thirteenth century was caused by the replacement of rye with wheat, an important source of *Fusarium* mycotoxins.

Mycotoxins occur in a wide variety of foods and feeds and have been implicated (Mayer, 1953; Coker, 1997) in a range of human and animal diseases. Exposure to mycotoxins can produce both acute and chronic toxicities ranging from death to deleterious effects upon the central nervous, cardiovascular and pulmonary systems, and upon the alimentary tract. Mycotoxins may also be carcinogenic, mutagenic, teratogenic and immunosuppressive.

2.6.5 Aflatoxins

Aflatoxins are toxic metabolites produced by certain fungi in/on foods and feeds . They are probably the best known and most intensively researched mycotoxins in the world. There are four major aflatoxins : B1 , B2 , G1 , G2 and two additional metabolic products , M1 and M2 , that are of significance as direct contaminants of foods and feeds. The optimal water activity for growth of *A. flavus* is high (about 0.99). The maximum is at least 0.998 whereas the minimum water activity for growth has not been defined precisely.

The term 'aflatoxins' was coined in the early 1960s when the death of thousands of turkeys ('Turkey X' disease), ducklings and other domestic animals was attributed to the presence of *A.flavus* toxins in groundnut meal imported from South America (Austwick, 1978).

Pitt and Miscamble (1995) have reported a minimum for growth of about 0.83; and a minimum for aflatoxin production of about 0.87. It was reported that optimal growth and toxin production occur at approximately 30 and 28^{o}C, respectively.

Nagy Halim Aziz *et al.* (1997) conducted a study on Contamination of some common medicinal plant samples and spices by fungi and their mycotoxins. A total of 84 medicinal plant samples and spices were examined for the contamination of molds and mycotoxins. Ten fungal genera of different taxonomic groups were detected. The molds produced high concentrations of mycotoxins in synthetic medium and low to zero concentrations in the medicinal plants.

2.7 Good Agricultural Practices (GAPs)

The term Good Agricultural Practices (GAP) can refer to any collection of specific methods, which when applied to agriculture, produce results that are in harmony with the values of the proponents of those practices. Good Agricultural Practices are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability. (Description of the UN FAO GAPs). GAPs may be applied to a wide range of farming systems and at different scales. The basic of good agricultural practices is the integration of application of new production systems such as Integrated Pest Management (IPM), Integrated Crop Management (ICM) and conservation agriculture.(http:// wikipedia.com)

Key areas of concern when implementing a GAP program are soil, water, crop and fodder production, crop protection, animal production, animal health and welfare, harvest and on-farm processing and storage, energy and waste management, human welfare, health and safety, wildlife and landscape.

2.7.1 Soil

It is important to know the physical and chemical condition of soil types across the farm as it directly affects productivity, irrigation management, fertilizer application rates and used soil management practices. The aim of good soil management is to maintain and improve soil productivity by appropriate crop rotations, manure application, pasture management.

2.7.2 Water

Careful management of water resources and efficient use of water for rain fed crop and pasture production, for irrigation where applicable, and for livestock, are criteria for GAP. The most efficient and commercially practical water delivery system should be used to ensure the best use of water.

2.7.3 Crop and Fodder Production

Crop and fodder production involves the selection of annual and perennial crops, their cultivars and varieties, to meet local consumer and market needs according to their suitability to the site and their role within the crop rotation for the management of soil fertility, pests and diseases, and their response to available inputs.

2.7.4 Crop Protection

Maintenance of crop health is essential for successful farming for both yield and quality of produce. Protection of crops against pests, diseases, and weeds must be achieved using appropriate control measures. Growers must understand and adopt IPM practices to minimize the potential impact of pest control actions on workers, food, and environmental and health safety. Good crop protection management aims to use resistant cultivars/varieties and maintain regular and quantitative assessment of the balance status between pests and diseases and beneficial organisms of all crops.

2.7.5 Animal Production

Livestock require adequate space, feed, and water for welfare and productivity.

2.7.6 Harvest and On-farm Processing and Storage

Product quality also depends upon implementation of GAP for harvesting, storage, and where appropriate, processing of farm products. Crops must be harvested in a manner to minimize contamination.

2.7.7 Energy and Waste Management

Energy and waste management are also components of sustainable production systems such as GAP. Good practices related to energy and waste management will include those that establish input-output plans for farm energy, nutrients, and agrochemicals to ensure efficient use and safe disposal. Fertilizers and agrochemicals must be stored securely and in accordance with legislation and an emergency action procedures must be established to minimize the risk of pollution from accidents.

2.7.8 Human Welfare, Health and Safety

Human welfare, health and safety are further components of GAP. Farming must be economically viable to be sustainable. Good practices related to human welfare, health and safety must achieve an optimum balance between economic, environmental, and social goals and provide adequate household income and food security.

2.7.9 Wildlife and Landscape

Agricultural land accommodates a diverse range of animals, birds, insects, and plants. Good practices related to wildlife and landscapes will include those that identify and conserve wildlife habitats and landscape features, such as isolated trees, on the farm and minimize the impact of operations such as tillage and agrochemical use on wildlife.

The benefits of the good agricultural practices include;

- The use of good agricultural practices during production, harvesting, sorting, packaging, and storage operations for crops is a key to prevent pathogen contamination.
- Producers and marketers will increase the chance of their competition power by documenting in quality and safety of their products in the more competitive markets.
- Retailers will be confident for the quality and safety of the products placed on their shelves.
- Consumers can buy certificated products without worrying any environmental damage and residue problem in the production and products.
- Sustainable use of natural resources will be considered.

Tawadchai Suppadit *et al.* (2006) conducted a study on adoption of good agricultural practices for beef cattle farming of beef cattle - raising farmers. The objectives of the study were to (1) investigate the basic conditions of beef cattle - raising farmers; (2) find the level of adoption of GAPs on beef cattle farming of beef cattle-raising farmers; (3) investigate factors related to the adoption of GAPs on beef cattle farming of beef cattle - raising farmers; and (4) find problems encountered in beef cattle-raising in accordance with GAPs for beef cattle farming. It was found that most of the beef cattle raisers employed GAPs at a moderate level. It was recommended that the farmers be supported on the more correct practices of raising beef cattle which is in line with GAPs for beef cattle farming.

Tim Brigham *et al.* (2004) conducted the project to develop Good Practices for Plant Identification for the Herbal Industry had its origins in consultations with industry and government representatives aimed at laying the groundwork for the safe use of natural health products. With the support of the Canadian On Farm Food Safety (COFFS) program, the National Herb and Spice Coalition set out to build a HACCP (Hazard Analysis Critical Control Points) model for the herb and spice industry. During the development of the HACCP model, the technical working group identified plant identification as one of the two most critical components of the Good Agricultural Practices (GAPs) that needed to be developed for the industry. Proper plant identification is one of the keys to the development of an industry based on the safe use of high quality natural health products.

Fatma Akkaya *et.al.* (2004) made a survey on Good Agricultural Practices (GAP) and its implementation for fruits and vegetables in Turkey. Turkey has capability of producing enough fresh fruit and vegetables not only for its own consumption, but also export. In 2001, Turkey provided about 2.5 % and 4 % of world's fresh fruit and vegetables production, respectively. However, export/production ratio is considerably low for Turkish horticultural crops. Establishing a consumer satisfied system such as GAP will provide important advantages for domestic and export markets. Therefore introducing and expanding the GAP system in Turkey will most likely provide some advantages to the other countries having a food-trade relation with Turkey. The main aims of this paper are to review existing knowledge regarding to GAP at the national and international level, to discuss the implementation of the GAP system in Turkey, to analyze GAP system and to determine the advantages for whole food chain participants.

2.8 Good Manufacturing Practices (GMPs)

Good manufacturing practices (GMPs) lie at the heart of quality. GMPs comprise a variety of practices that ensure quality including things such as:

- raw materials quality assurance
- record-keeping of substances throughout the manufacturing process
- standards for cleanliness and safety
- qualifications of manufacturing personnel
- in-house testing
- production and process controls
- warehousing and distribution

GMPs provide quality assurances that off-the-shelf testing cannot. Off-the-shelf testing relies upon random sampling of a very small subset of the final product. Enormous resources must be expended to test one substance - testing just a few samples of each brand. These tests provide only a snapshot-in-time view of a product's quality. Fluctuations in product quality are slow to be discovered via such after-the-fact testing. In contrast, GMPs provide continual measures of quality that can uncover problems and fluctuations as they occur and before the product is shipped. Thus, GMPs are a more immediate and consistent way to control quality.

The need for GMPs takes on further importance because the issues involved in developing test methods for dietary supplements are many and complex. Until methods are further developed, standardized, and widely accepted, GMPs serve as a primary vehicle for ensuring quality. (http:// supplements quality.com). GMP is sometimes referred to as ‘cGMP’,where the ‘c’stands for ‘current’ reminding manufacturers that they must employ technologies and systems which are up-to-date.

2.9 Hazard Analysis Critical Control Point (HACCP)

Hazard Analysis Critical Control Point (HACCP) is the internationally recognized and recommended approach to ensure food safety. It is an analytical tool that enables management to introduce and maintain a cost-effective, ongoing food safety program.

HACCP involves the systematic assessment of the steps involved in a food manufacturing operation and the identification of those steps that are critical to the safety of the product. The analysis allows management to concentrate resources into those manufacturing steps that critically affect product safety. A Hazard analysis will produce a list of Critical Control Points (CCPs), together with control parameters (with critical limits), monitoring procedures and corrective actions for each CCP. For continuing safety and effectiveness of the plan, records must be kept of each analysis and the efficacy of the study must be verified on a regular basis, and when aspects of the operation change. (American Spice Trade Association, Inc., 2006)

HACCP is a powerful system, which can be applied to a wide range of simple and complex operations. It is used to ensure food safety at all stages of the food chain. For manufacturers to implement HACCP, they must investigate not only their own product and production methods but also apply HACCP to their raw material supplies, final product storage, and consider distribution and retail operations up to and including the point of consumption.

HACCP is applicable to the identification of microbiological, chemical, and physical hazards affecting product safety. It may be applied equally to new or existing products. It requires the full commitment of management to provide the resources necessary for successful analysis and implementation. Much of the effectiveness of HACCP is achieved through the use of multidisciplinary team of experts. The team should have members from relevant areas; e.g., microbiology, chemistry, production, quality assurance, food technology, and food engineering. (National Advisory Committee on Microbiological Criteria for Foods, 1999)

HACCP is a system which identifies specific hazard(s) (i.e. any biological, chemical, or physical property that adversely affects the safety of the food) and specifies measures for their control. The system consists of seven basic principles as described below.

Principle 1: Conduct a hazard analysis

Step 1: Identify the hazards to human health that may be introduced into the food product, microbiological, chemical, and physical.

Step 2: Identify preventative measures that could be used to control the food safety hazard.

Principle 2: Identify Critical Control Points

A Critical Control Point (CCP) is a step in a food process at which control can be applied and, as a result, a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.

Principle 3: Establish Critical Limits for Each CCP

Critical limits are the boundaries of safety for preventive measures put in place at CCPs. A critical limit will usually be a reading or observation such as temperature, time, pH, etc. A critical limit can be an upper limit where a set amount or level cannot be exceeded. A critical limit can also be a lower limit where a minimum amount is required to produce the safe effect.

Principle 4: Establish Monitoring Procedures

Monitoring procedures are routine tasks, either by employee or by mechanical means that measure the process at a given CCP and create a record for future use. Continuous monitoring is preferred when it is possible. It is important that the person responsible for the CCP monitoring is given a specific, documented, CCP training.

Principle 5: Establish Corrective Actions

Establish corrective actions to be taken when monitoring shows that there is a deviation from a critical limit. Listed below are some questions that might help when developing corrective actions:

- How will people be informed when the deviation occurs?
- Who will be responsible for controlling the product that may have been affected by the deviation?

- How will we decide what caused the deviation?
- Who will be involved in deciding how to get the process back in control?
- Who in the company needs to sign off on any modifications to plan?
- Who will be responsible for keeping the records of things done in response to a deviation from a critical limit?

Principle 6: Establish Record keeping Procedures

Record keeping is an essential feature of a HACCP plan. Use simple understandable forms. Make sure employees know exactly what is expected if they are responsible for making a record entry. Make sure the records are signed and dated at the time a specific event occurs.

Principle 7: Establish Verification Procedures

Verification procedures are needed to make sure the plan is working correctly. There are three types of verification:

- **Validation**, the initial phase in which the plan is tested and reviewed.
- **Ongoing verification**, that ensures that the HACCP plan is working effectively on a day-to-day basis. Typically verification includes management review and sign off.
- **Reassessment**, an overall review of the plan that must be performed at least annually, or whenever any changes occur that could affect the hazard analysis or alter the HACCP plan.

The benefits from the use of HACCP are many. Key benefits are:

- HACCP is a systematic approach covering all aspects of food safety from raw materials, growth, harvesting and purchase to final product use.
- Use of HACCP will move a company from a retrospective end product testing approach towards a preventative Quality Assurance approach.
- HACCP provides for a cost-effective control of food borne hazards.
- A correctly applied HACCP study should identify all currently conceivable hazards, including those which can realistically be predicted to occur.

- Use of a preventative approach leads to reduced product losses.
- Use of HACCP focuses technical resources on critical parts of the process.
- HACCP is complementary to other quality management systems.
- U.S. regulatory and international authorities approve HACCP as an effective means for controlling food borne diseases.

2.10 Hazards involved in process line

The concept "hazard" in the HACCP terminology is expressed in terms of a danger to food safety from a biological, chemical or physical point of view. The term "hazard" refers to any part of a production chain or a product that has the potential to cause a safety problem. A critical control point is a point, step, or procedure at which control can be exercised to prevent, eliminate, or minimize a hazard. In the HACCP system specific dangers are identified all along the lifetime of a food product and the measures to manage (or control) these dangers.

2.10.1 Biological hazards

Biological hazards can be divided into three types: bacterial, viral, and parasitic (protozoa and worms). Many HACCP programs are designed specifically around the microbiological hazards. The incidence of food borne illness ranges from 12.6 to 81 million cases per year with hazard costs of 1.9 to 8.4 billion dollars. HACCP programs address this food safety problem by assisting in the production of safe wholesome foods.

2.10.2 Chemical hazards

Webster defines a hazard chemical as any substance used in or obtained by a chemical hazard process or processes. All food products are made up of chemicals, and all chemicals can be toxic at some dosage level. However, certain hazardous chemicals are not allowed in food and others have had allowable limits established. A summary of most of the chemical hazards in food has been drawn up.

The two types of chemical hazards in food are naturally occurring ones and added chemicals. Both may potentially cause chemical intoxications if excessive levels are present in hazardous food. Many HACCP programs have been criticized for their relative neglect of chemical and physical hazards.

2.10.3 Physical hazards

It is often described as extraneous matter or foreign objects, include any physical matter not normally found in food, which may cause illness (including psychological trauma) or injury to an individual. The most often reported complaint concerning physical hazards is that foreign objects provide tangible evidence of hazard product deficiency. Regulatory action may be initiated when agencies find adulterated foods or foods that are manufactured, packed or held under conditions whereby they may have become contaminated and may be injurious to health.

The hazard analysis portion of HACCP involves a systematic study of the ingredients, the food product, conditions of processing, handling, storage, packaging, distribution, and consumer use. This analysis helps to identify the sensitive areas in the process flow that might contribute to a hazard. This information can then determine the CCPs in the system that have to be monitored. A CCP is any point in the chain of food production from raw materials to finished product where loss of control could result in an unacceptable food safety risk.

John G. Surak *et al.* (1998) applied Hazard Analysis Critical Control Point as a food safety management system to ensure the safe production and packaging of food. The HACCP process has both strengths and limitations. It provides a systematic and effective method to analyze a process, and identifies potential biological, chemical and physical hazards that can occur in food. In addition, HACCP requires the development of strategies to prevent the inclusion or reduction of these hazards to an acceptable level in the food.

Michele.F.Panunzio *et al.* (2007) conducted study on the evaluation of HACCP plans in food industries located in the territory of the local health authority (LHA) of Foggia, Italy. The general errors (terminology, philosophy and redundancy) and the specific errors (transversal plan, critical limits, hazard specificity, and lack of procedures) were standardized. Concerning the general errors, terminological errors pertain to half the plans examined, 47% include superfluous elements and 60% have repetitive subjects. With regards to the specific errors, 77% of the plans examined contained specific errors. The evaluation has pointed out the lack of comprehension of the HACCP system by the food companies and has allowed Food and Nutrition Health Service, in its capacity as a control body, to intervene with the companies in order to improve designing HACCP plans.

Peter Bryar (2004) conducted study on the application of the Hazard Analysis Critical Control Point (HACCP) methodology in Australian horticulture crops to prevent or eliminate the food safety risk in fresh produce or reduce it to an acceptable level. HACCP has had a significant impact in the reduction of food borne illness relating to the consumption of fresh (and processed) horticultural produce and in the management of farm chemical residues. It has also assisted in the management of physical contamination. Although HACCP was designed for food safety purposes, there has been strong support in its application to manage produce quality risk resulting in an improvement in the consistency of quality of fresh fruit and vegetables. There is also strong evidence to suggest that the application of the method can lead to increasing awareness of new ways to deal with existing problems and improve or widen the scope of operational processes.

The purpose of this document is to outline GAP, GMP and HACCP principles to the spice industry and to develop generic models for spice industry use.

MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

In this chapter the raw material, the schedules for data collection from farmers and industrialists, quality analysis of collected samples and the list of equipments used for the analysis are presented.

3.1 Raw material

Raw material includes different products of pepper (*Piper nigrum L.*) namely black pepper, white pepper, dehydrated green pepper which were procured from the various industries in Wayanad district. The raw materials collected were kept in air tight package under hygienic conditions.

3.2 Data collection

A survey was conducted in Wayanad which is the major pepper producing district in Kerala. Schedules for data collection were prepared both for industries and farmers in English and Malayalam. Questionnaire prepared for farmers include questions regarding source of the vine, irrigation practices, fertilizer application, pesticide application, soil, cultural practices, storage, documentation of operations etc. We surveyed four regions of the district namely, Mananthavady, Pulpally, Sultan Bathery and Ambalavayal and collected information from a minimum of five farmers from each area. (Plate No. 3.1)

Information regarding the collection of raw material, process line, hygienic practices undertaken, packaging, storing etc after visiting four industries in the aforementioned regions were also analyzed.

3.2.1 Questionnaire for data collection from farmers

In order to reinforce the survey, a list of questions was prepared covering almost all aspects of agricultural practices at the farmer's level. The questionnaire involved the following questions

1. Name
2. Address
3. Certified or not
4. Total area
5. Crops cultivated
6. Area under pepper
7. No: of vines
8. Variety of pepper
9. Source of the vine
10. Method of irrigation
11. Type of fertilizer
12. List of fertilizers
13. Pesticide application
14. Method of harvest
15. Method of threshing
16. Farm level processing
17. Total yield
18. Type of packing
19. Type of storage
20. Marketing
21. Documentation

Plate No. 3.1 Data collection from farmers

3.2.2 Industries visited:

The industries visited include Wayanad Spices Processing Centre (Mananthavady), St. Mary's Spice and Condiments (Pulpally), Palia Brothers Manufacturers or Exporters (Sulthan Bathery), Kuriakose Brothers Spices (P) Ltd. (Sultan Bathery), for analyzing the process line , understanding the on going unit operations, and evaluating the quality of the products from the respective industry.

3.2.2.1 Wayanad Spices Processing Centre

Wayanad Spices Processing Centre located at Dwaraka, Mananthavady is one among the major pepper exporters in the region, without HACCP certification. Capacity of the plant is about 2.5-3 t/day. (working under Wayanad Social Service Society, WSSS) (Plate No. 3.2)

Plate No. 3.2 Wayanad Spices Processing Centre

They procured the raw material (fresh/dried berries) from about 2400 farmers on contract basis, out of which 540 farmers were organic certified and the remaining were about to get the certification. They had an efficient team comprising of managers, supervisors and farmers to ensure the quality of the raw material. Parameters like moisture content and litre-weight were determined at the field level to assess the quality of the raw sample. Pepper was collected from field in polythene bags marked with farmer's code and lot number (to ensure traceability) with details including the specifications of the farmer and the date, month and year of procurement. Samples from each lot were tested and the results recorded. These samples were retained for one year to trace the default lot, so that they can be rejected to ensure the supreme quality of the products. The main products from the industry were ginger, black pepper & white pepper.

Production of black pepper

Raw sample (dried berries) from the store house was conveyed through a bucket elevator to destoner (cleaning) for the removal of stones or any other heavy particles present in the sample and was then fed to the spiral separator (grading) to separate them based on their size or sphericity. Accordingly they were classified as low grade and high grade. Low grade is fed to pulverizer and make into powder and packed. A sample of the high grade is tested and is packed for export. (Fig.3.1)

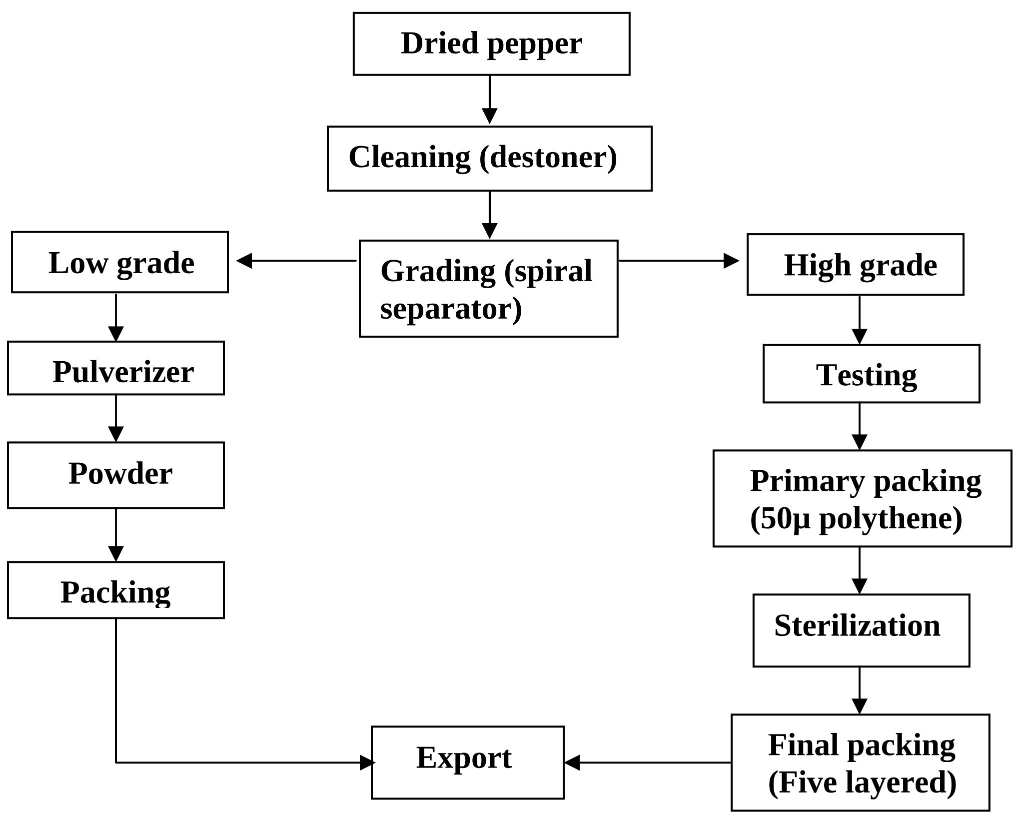


Fig. 3.1 Flow diagrams for the production of black pepper
[*Wayanad Spices Processing Centre*]

Production of white pepper

White pepper is manufactured by fermentation of raw or dried sample under anaerobic condition (Fig. 3.2). The processing unit consisted of three tanks, one cylindrical shaped mother tank and two fermentation tank (one cylindrical & one tunnel shaped). They observed that the tunnel shaped unit is more efficient since it provided more space.

Both black and fresh pepper was used for fermentation. Black pepper was fermented for about 5-6 days and fresh pepper for about 3-4 days. *Bacillus* spp. bacteria cultured in the mother tank were used for fermentation. Coffee husk and pepper waste were used as culture media.

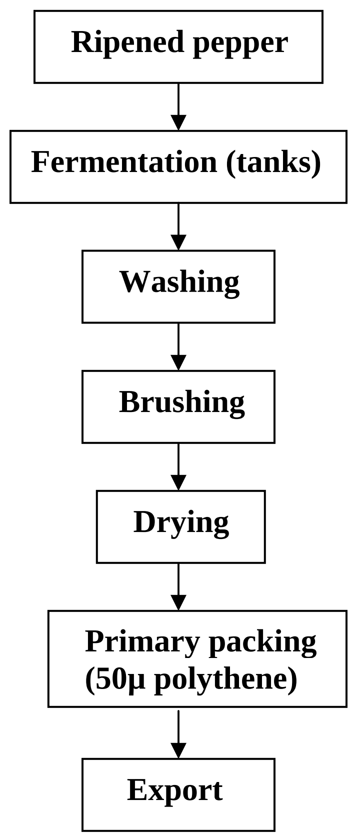


Fig. 3.2 Flow diagram for the production of white pepper

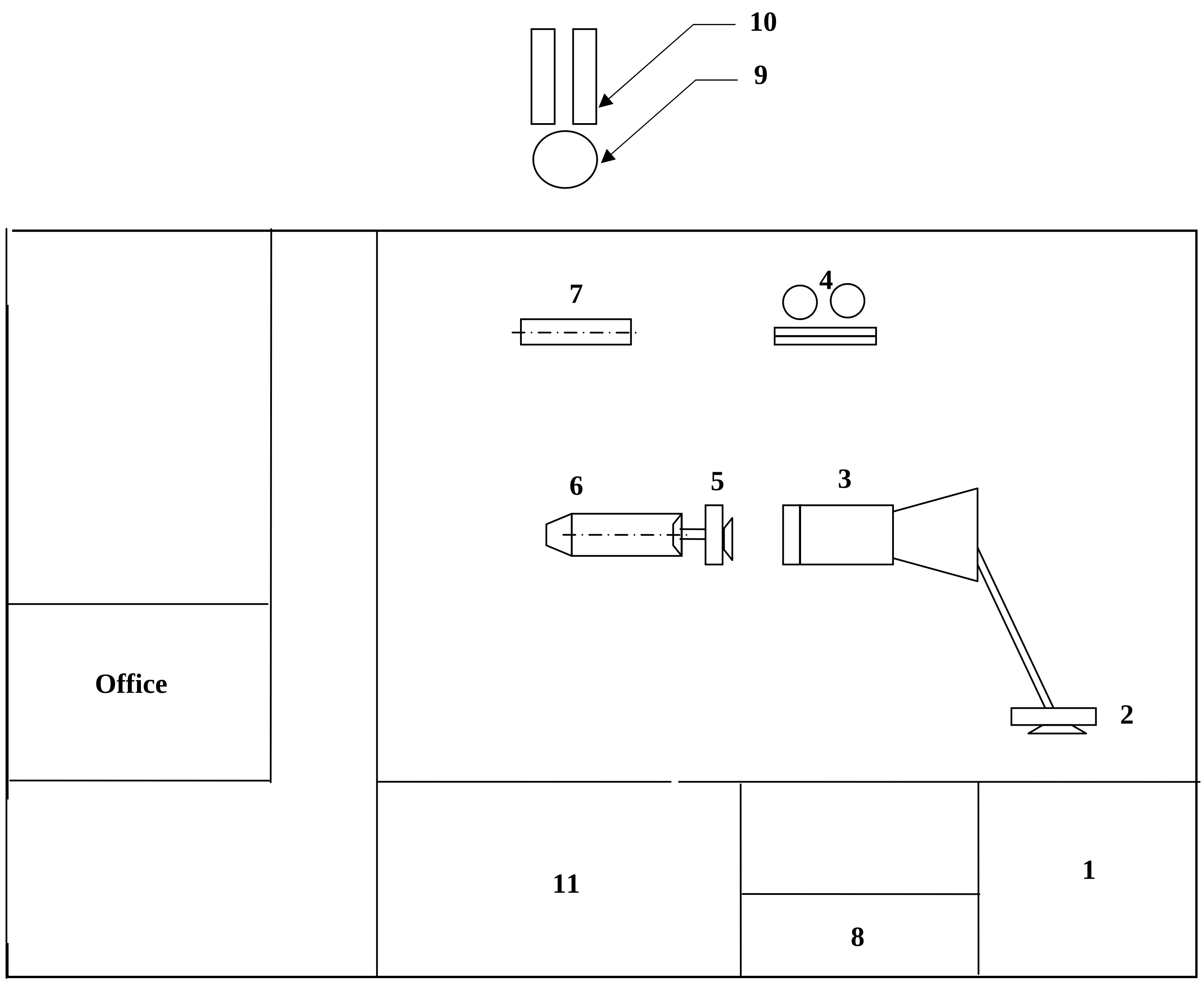
The bag containing green pepper was hooked on the top for keeping it in floating position, whereas for black pepper the bag was allowed to sink to the bottom for better contact with the bacterial culture so as to ensure effective removal of pericarp of berries.

The product after fermentation was fed to pulping machine (pulper) for making good quality white pepper and sun dried. After drying to safe moisture content the product was packed.

The industry was not equipped with a sterilizing unit but they availed the facility at Ernakulam, if necessary, as recommended by the customer. Even though not certified, they maintained good record of their processes and their products and its quality. The products are tested at Spices Board, SGS lab or RRL lab once or twice a year. They mainly focussed on the determination of microbial load and they try to keep this value around 3500TPC which is far less than the permissible limit of 1lakh TPC.

Both black pepper and white pepper were primarily packed in 50μ polythene bags and then finally with five layered polythene bags. The products after final packing were shifted to store houses and kept above wooden pallets to avoid the moisture migration from floor.

After analyzing the flow process line in the industry an existing plan of the equipments and their layout were drawn for further study and to suggest modifications as per the HACCP and GMP principles. (Fig. 3.3)



1. Store (raw material)
2. Bucket elevator
3. Destoner
4. Spiral Separator
5. Bucket elevator
6. Brushing machine
7. Pulper
8. Packing
9. Mother tank
10. Fermentation tank
11. Finished product store

Fig. 3.3 Schematic of existing plant layout [*Wayanad Spices Processing Centre*]

3.2.2.2 St. Mary’s Spices and Condiments

St. Mary’s Spice and Condiments, Pulpally, started in the year 2006, is a medium scale exporter of pepper and processed products without HACCP certificate (Plate No. 3.3). They collect raw material (fresh green pepper) from both organic and conventional farmers. Dried samples are not processed in the industry. The value added products from the industry were dehydrated green pepper, pepper in brine and black pepper of export quality. Products were mainly exported to Germany.

The industry has applied for HACCP certification through an organization at Cochin and is implementing the modifications as recommended by the agency.

Plate No. 3.3 St. Mary’s Spices and Condiments

The flow process line in the industry and existing plan of the equipments and their layout were drawn to analyze and to recommend modifications. (Fig 3.6)

Dehydrated green pepper

Green pepper was boiled in a double layered steam jacketed kettle made of stainless steel (304 grade). Then transferred to a sieving bucket to remove water and kept for 10 minutes for cooling. These buckets were lifted with the help of a crane and the contents placed in water filled tanks for cooling for 4 hours. Later the contents were transferred to perforated trays at the rate of 3kg per tray and dried for 5½ hours in a drier. There were eight driers each having a capacity of 600kg (200 trays). The temperature of the drier was set initially at $100^{o}C$ for 1 hour and then gradually reduced up to $70^{o}C$. The final product i.e., dehydrated green pepper was spread on the ground for cooling and then graded with spiral separator to be finally packed in sacks. (Fig. 3.4)

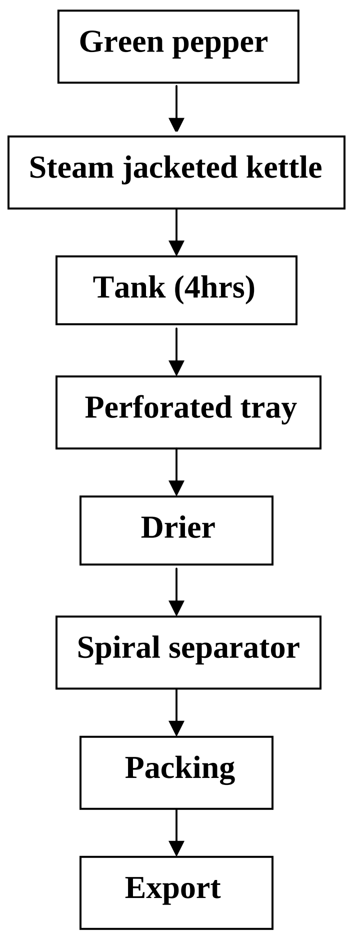


Fig. 3.4 Flow diagram for the production of dehydrated green pepper

Pepper in brine

Pepper in brine is another product of high export value processed form green pepper. In its production green pepper was kept in 17 % brine solution (2% acetic acid, 0.25% citric acid and 100ppm SO_2) for a period of 45 days before washing with water, drying and packing. The products were packed in polythene bags and stacked. (Fig. 3.5)

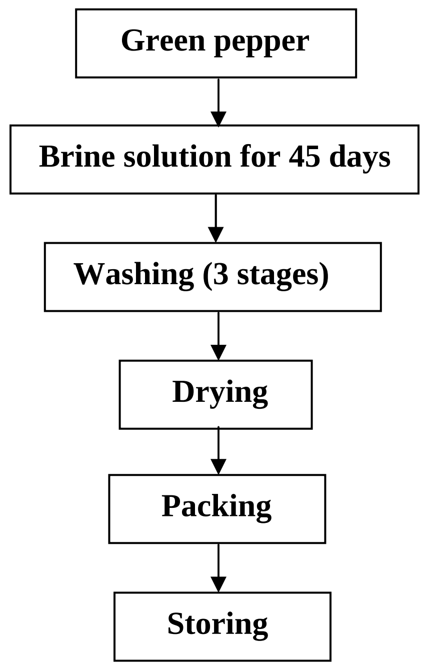
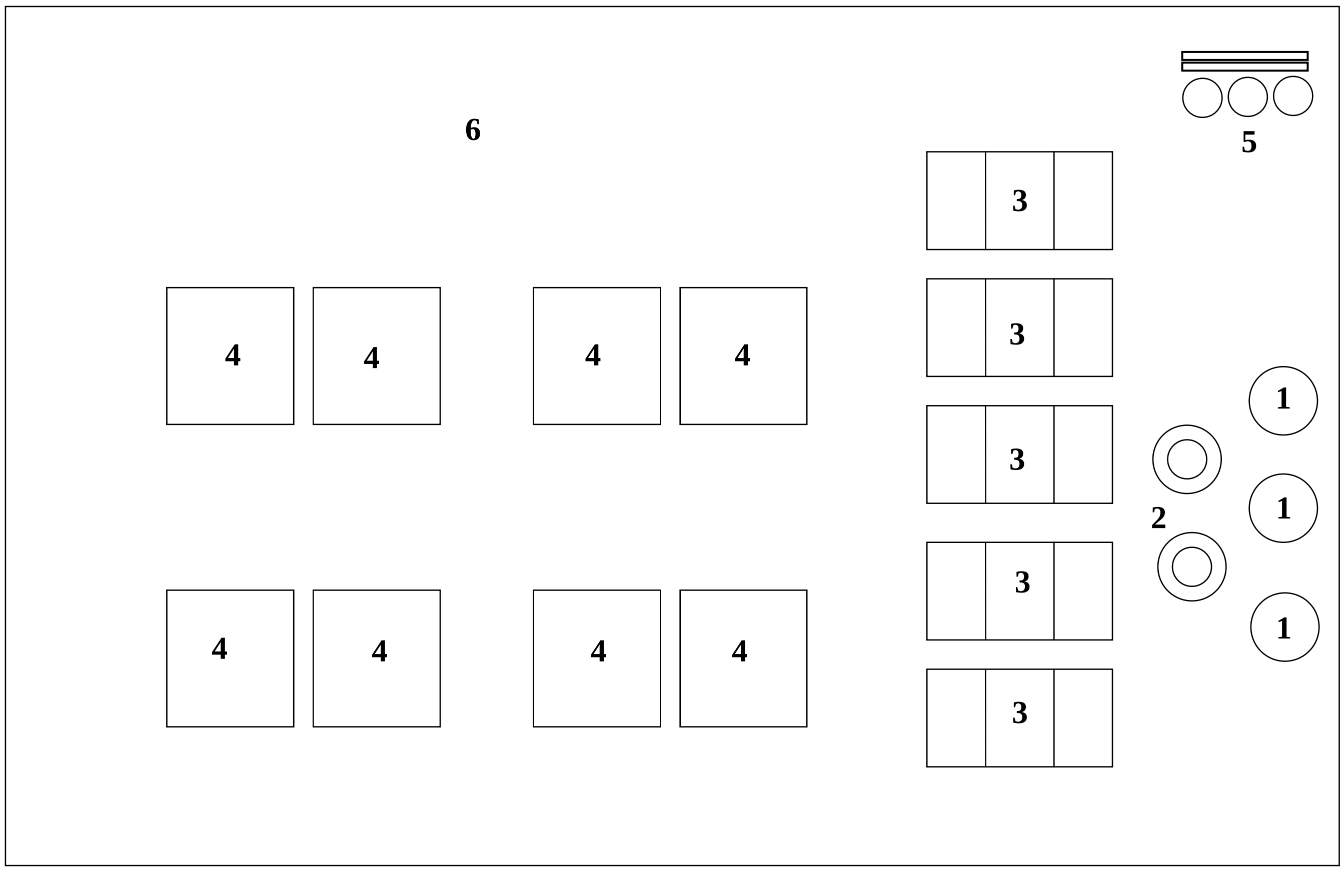


Fig. 3.5 Flow diagram for the production of pepper in brine



1. Steam jacketed kettle
2. Sieving bucket
3. Cooling tanks
4. Drier
5. Spiral separator
6. Store

Fig. 3.6 Schematic of existing plant layout [*St. Mary's Spices & Condiments*]

3.2.2.3 Palia Brothers Manufacturers and Exporters

Palia Brothers Manufacturers and Exporters is a small scale exporting unit of black pepper located near Sultan Bathery (Plate No. 3.4). Raw materials (fresh/dried berries) collected from traders and farmers were garbled and exported, to different parts of India.

Plate No. 3.4 Palia Brothers Manufacturers and Exporters

The raw sample was fed into the specific gravity separator through the bucket elevator to separate light foreign materials and later fed to the grader to separate it according to the size. Pneumatic feeding was to remove fine dust. Then the produce was dried in a shallow bin drier and packed. The capacity of the plant is 12 tones per day. (Fig. 3.7)

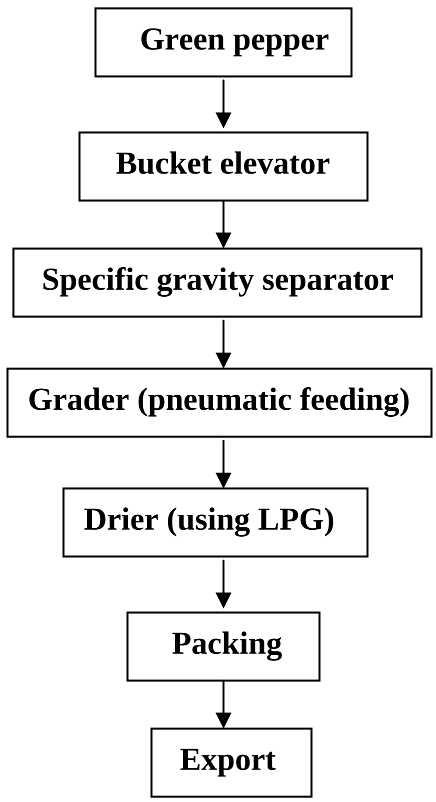
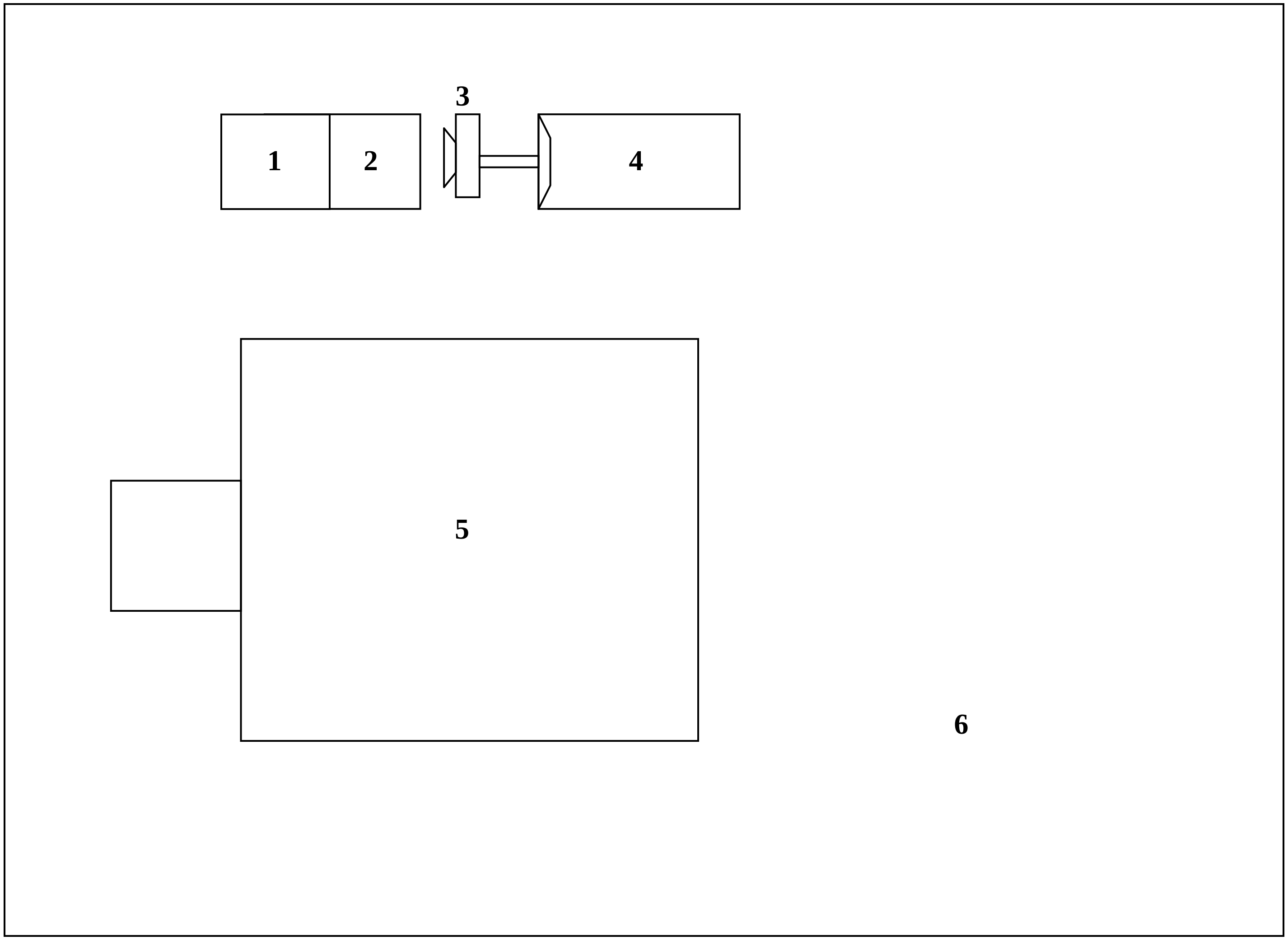


Fig. 3.7 Flow diagram for the production of garbled pepper



1. Specific gravity separator
2. Grader
3. Bucket elevator
4. Destoner
5. Drier (Shallow bin)
6. Store

Fig. 3.8 Schematic of existing plant layout [*Palia Brothers Manufacturers and Exporters*]

3.2.2.4 Kuriakose Brothers Spices (P) Ltd.

Kuriakose Brothers Spices (P) Ltd. is a medium scale industry located at Sultan Bathery which was not HACCP certified (Plate No. 3.5). The raw material (black pepper) procured from dealers were processed and sold to the exporters. The existing process line and the layout is as shown in Fig. 10.

Plate No. 3.5 Kuriakose Brothers Spices (P) Ltd.

The raw material was fed into the destoner to remove stones or other foreign particles, if any, and then to spiral separator through the bucket elevator. Here a separate grader was also used in addition to the spiral separator to get three grades of pepper. Oil wash unit was used for polishing the pepper. Finally pepper was dried in a deep bin drier and packed in polythene bags. (Fig. 3.9)

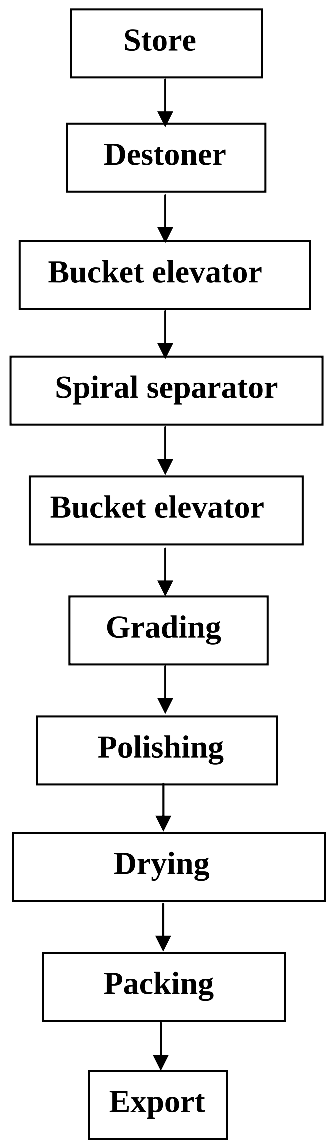
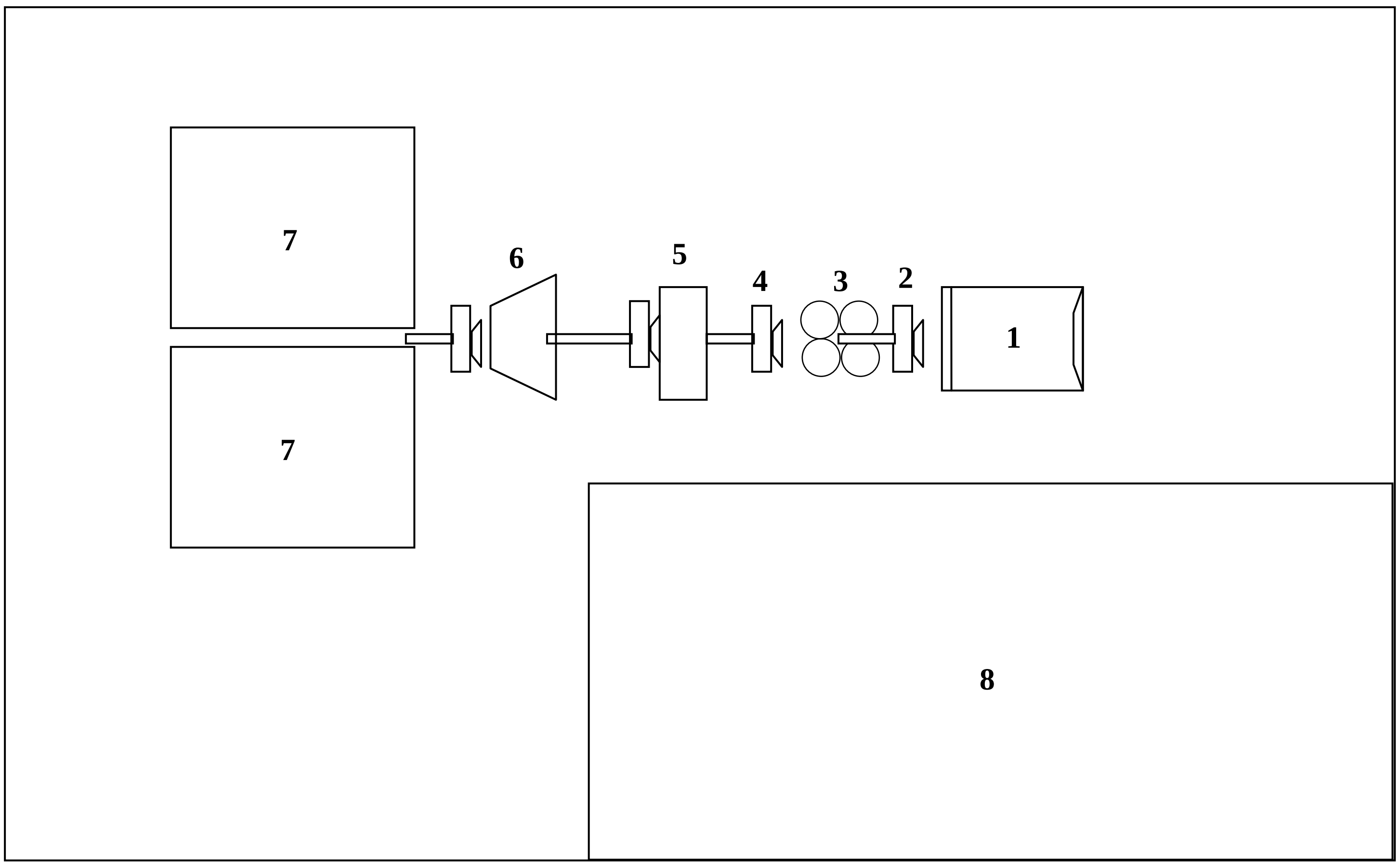


Fig. 3.9 Flow diagram for the production of black pepper

[*Kuriakose Brothers Spices (P) Ltd.*]



1. Destoner
2. Bucket elevator
3. Spiral separator
4. Bucket elevator
5. Grader
6. Garbling
7. Drier
8. Store

Fig. 3.10 Schematic of existing plant layout [*Kuriakose Brothers Spices (P) Ltd.*]

3.3 Quality analysis of collected samples

Quality which is referred as ‘the fit & customary for the purpose intended’ can be assured if all the parameters that affect it lies within permissible limits. For this the pepper samples were subjected to quality analysis and the three important factors that affect quality i.e., moisture content, volatile oil and oleoresin were determined.

3.3.1 Determination of moisture content

Moisture content was determined by toluene distillation method using Dean Stark apparatus as per Associates of Official Analytical Chemists (AOAC, 1975) method (Plate 3.6).

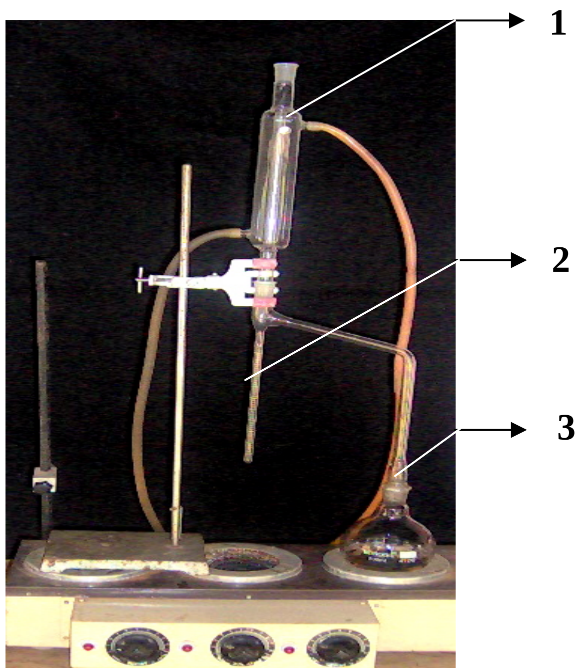


Plate No. 3.6 Dean Stark Apparatus

1. Condenser
2. Dean Stark Apparatus (moisture collected)
3. Round Bottom Flask (Sample + Toluene)

Predetermined quantity (100ml) of Toluene was taken in a distillation flask containing 5 g of ground black pepper sample. The flask was attached to the Dean Stark apparatus with the condenser. On boiling, the water vapour along with toluene got distilled from the flask, and gets condensed, and was trapped in the receiver of the apparatus, which contained toluene. Distillation was continued till the volume of moisture collected remained constant. The apparatus was cooled at room temperature and weight of moisture collected was noted.

The moisture content was calculated by,

$$\text{M.C. (w.b), \%} = \frac{W_w}{W} \times 100 \qquad -$$

Where,

W_w = Weight of water collected, g

W = Initial weight of sample, g

M.C (w.b) = Moisture content, % wet basis

3.3.2 Volatile oil

This is a measure which helps to identify the adulteration of spice (pepper) by addition of foreign materials, low quality or spent amounts of the raw material. The volatile oil content was estimated by distillation method using Clevenger apparatus as shown in plate below (Plate No. 3.7).

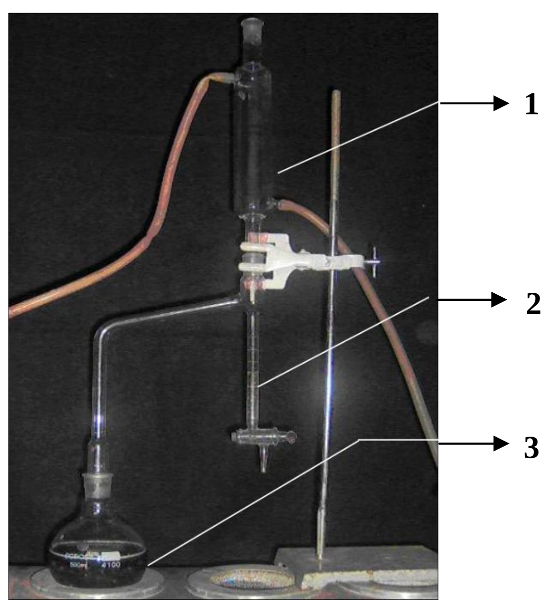


Plate No. 3.7 Clevenger apparatus

1. Condenser
2. Clevenger Apparatus (oil collected)
3. Round Bottom Flask (Sample + Distilled water)

About 20 g powder and 200 ml distilled water were taken in a round bottom flask and attached to the Clevenger apparatus with a condenser. On boiling, the oil was collected in the receiver of the apparatus which contained distilled water. The distillation was carried out for 2 hours. Volume of oil collected after cooling was expressed as,

$$\text{Volatile oil, \%} = \frac{V}{W} \times 100$$

Where, V = Volume of oil collected ml, assumed g

W = Total weight of the sample, g

3.3.3 Oleoresin

The oleoresin was extracted with n-hexane by using a solvent extraction method using a Soxhlet extraction apparatus (Plate No. 3.8).

Plate No. 3.8 Soxhlet extraction apparatus

Pepper powder of 20 gram was packed in a thimble and kept in the extraction tube of the Soxhlet apparatus. About 75 ml of n-hexane was taken in the Soxhlet flask and attached to the extraction tube along with a condenser. The extraction was continued for four hours (six cycles) on water bath. At the end of the extraction period, the pepper powder packet was removed from the apparatus and distilled further for the removal of the solvent. The last traces of the solvent were removed at room temperature using a vacuum pump. Quantity of oleoresin was calculated as

$$\text{Oleoresin, \%} = \frac{\text{Weight of extracted oleoresin}}{\text{Initial weight of pepper powder}} \times 100$$

3.3.4 Microbiological analysis

The microbial load of the collected sample and their respective homogenates were estimated by means of serial dilution procedure.

3.3.4.1 Serial dilutions test:

In this method the organism that is most abundant in a known volume of original sample is isolated and quantified. Measured quantity (10g) of the sample (pepper powder) was dissolved in 90ml of sterile water in a 250 ml conical flask and mixed it thoroughly with a shaker to give 1: 10 (10^{-1}) dilution of original sample. From these solutions 1ml was taken and added to 9ml of sterile water which gave 1:100 (10^{-2}) dilution of the original sample. Serial dilutions of 1:1000, 1:10000, and so on dilutions of the original sample up to 10^{-8} were prepared. Dilutions of 10^{-8}, 10^{-3} and 10^{-5} were used respectively to bacteria, fungus and actinomycetes estimation.

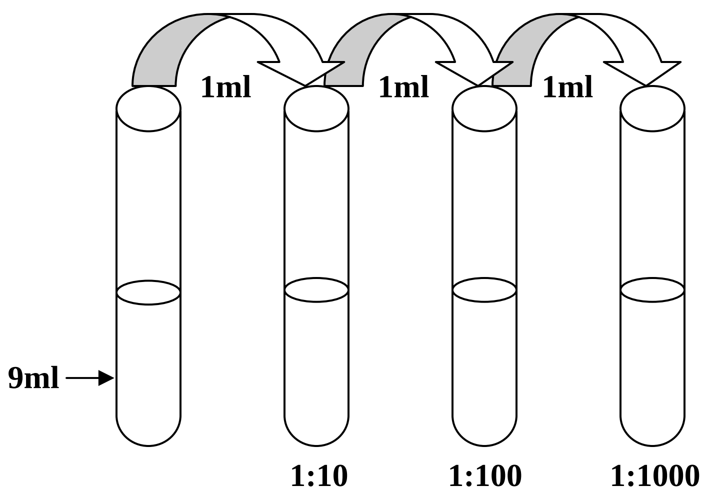


Fig. 3.11 Diagram representing serial dilution procedure

Finally one ml of required dilution (depending on the type of microorganism) was added to a sterile Petri dish to which 9ml of sterile, cool, molten medium (like nutrient agar, potato dextrose and Czapekdox media) was added. A minimum of three replications was attempted for more accuracy. After 3-7 days of incubation at 28 ± 2 ^{0}C or room temperature,depending on the organism, the number of colonies were counted. This number multiplied by the dilution factor to find the total number of cells per ml of the original sample. The estimated number of bacteria in the sample was computed using following formula

$$B = N/D$$

D = dilution factor (either 1, 10 or 100)

B = number of bacteria

N = number of colonies counted on a plate

In a dilution, the dilution factor is equal to the ratio of final volume to the initial volume of solution but for serial dilution, it is the product of individual dilution factors.

Media preparation

Media for culturing different microorganisms like bacteria, actinomycetes and fungus were prepared. For bacteria the media used was nutrient agar, for fungus potato dextrose media and for culturing actinomycetes, czapekdox media was used. The media after preparation was stored in sterile conditions.

Media composition

The media composition may vary according to the type of microorganism to be cultured. Each media for a specific microorganism is prepared by mixing different components in suitable proportion.

Nutrient agar media

- Beef extract = 0.3g
- Peptone = 5g
- Sodium chloride = 5g
- Agar = 18g
- Distilled water = 1000ml

Potato dextrose media

- Peeled potato = 250g
- Dextrose = 20g
- Agar = 18g
- Distilled water = 1000ml

Czapekdox media

- Sucrose = 30g
- Sodium nitrate = 2g
- Potassium hydrogen phosphate = 1g
- Magnesium sulphate = 1g
- Potassium chloride = 0.5g
- Ferrous sulphate = 0.01g
- Agar = 18g
- Distilled water = 1000ml

Incubation temperatures

- Bacteria : 28 ± 2^0 C for 3 days
- Fungus : 28 ± 2^0 C for 5-7 days
- Actinomycetes: Room temperature for at least 7 days

Colony Forming Unit (cfu)

In microbiology, colony-forming unit (cfu) is a measure of viable bacterial numbers. Unlike in direct microscopic counts where all cells, dead and living, are counted, 'cfu' measures viable cells. By convenience the results are given as, colony-forming units per millilitre. The theory behind the technique of 'cfu' establishes that a single microorganism can grow and become a colony, via binary fission. These colonies are clearly different from each other, both microscopically and macroscopically. However, some microorganism does not separate completely during the sample preparation process and the results of the count will be below the number of individual cells using direct methods.

3.3.5 Materials and Equipments used

3.3.5.1 Glass wares

The different glass wares used are Petri dishes, pipettes, conical flask, test tubes, measuring cylinder, and stirring rod for the microbial analysis.

3.3.5.2 Hot air oven

Hot air oven (605 x 605 x 910mm) inside of stainless steel with digital display cum controller and air circulating fan was used. Glass wares were kept at 160^0 C for 2 hours for complete sterilization.

Plate No. 3.9 Hot air oven

3.3.5.3 Autoclave

Autoclave of vertical type (YSI-403 model) of size 300 x 500mm was used. are made from stainless steel and help to check the spread of infections.

Plate No. 3.10 Autoclave

3.3.5.4 Rotary shaker

Rotary shakers which are ideal for mixing and development of cultures chemicals etc. was used for making the stock solution of pepper powder. Conical flasks are used for shaking the solutions in it. This promotes the homogenous mixing and dissolving of the substance contained in the flask. It has a maximum speed of 250 rpm.

Plate No. 3.11 Rotary shaker

3.3.5.5 Microwave oven

A Kenstar microwave oven (MWO – 9808 series model), of outside dimensions 465 x 274 x 352 mm was used. Microwave ovens heat food quickly, efficiently, and safely, but do not brown or bake food in the way conventional ovens do.

Plate No. 3.12 Microwave oven

3.3.5.6 Laminar air flow

A horizontal laminar air flow system (4 x 2 x 2 ft) which is specially designed and developed to be used in laboratories was used. Laminar air flow system efficiently filters dust particles up to 0.3 microns and also eliminates microorganisms by killing them during the filtration process through U.V. radiation and electrostatic precipitation.

Plate No. 3.13 Laminar air flow

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

In this chapter, results of the survey among the farmers and industries, and the experiments for the determination of different quality parameters are discussed and the modifications in the process line of the industries are also presented.

4.1 Survey among farmers

The farmers in the sample survey were growing spices in their own farms with vines prepared by them. The classification of the farmers according to the land holding revealed that 10% of the total farmers were in the small-scale category (< 1 acre); 70% were in the medium-scale group (1-4 acre); and 20% in large-scale group ($\geq$4 acres). Some farmers were organic certified (27%) and the remaining were either about to get the certification or followed the conventional farming system.

Almost all the farmers were cultivating common varieties of pepper namely Panniyur and Karimunda with rainwater as the source of irrigation along with other crops. Majority of the farmers (80%) were using bio-fertilizers like neem cake, cow dung, *Pseudomonas spp.*, *Trichoderma spp.* etc for the spice production, whereas 15% were using chemical fertilizer and the remaining farmers neither adopted bio-fertilizer nor chemical fertilizer. About 75% of the farmers used Boudreaux mixture as pesticide and rest did not resort to any pesticides for the control of pests.

All the farmers harvested the matured berries manually and threshed mechanically by 70% of the farmers and remaining followed manual methods such as trampling, beating with stick or by hand for separating berries from the spikes.

All the farmers preferred sun drying of harvested berries as it is the most common and cheapest method of drying. Blanching was carried out prior to drying by about 60% of the farmers surveyed, for improving the appearance as well as quality of the produce. Nevertheless, only a few are processed dried pepper for producing white pepper to enhance the market value.

Only a few of the farmers (10%) stored their products in polythene bags before storing in jute bags. All the farmers other than organic certified farmers sold their products to local markets while organic farmers sold their product directly to industries.

Documentation of the agricultural practices and processes carried out for the production of their commodities were properly done only by the certified farmers.

4.2 Survey among processors

The industries visited were not HACCP certified. Out of the four industries visited, two plants were concentrating on export as well as organic pepper processing. However the other two concentrated in domestic supply. They procured the raw material (fresh/dried berries) from farmers on contract basis. The industrial personnels at various levels ensures the quality of the raw material ingoing the plant. All processing centers were keen in checking the raw material quality at the collection point itself.

The price of raw material was fixed based on the parameters, viz; moisture content, per cent of foreign material and litre-weight. The traceability is ascertained by providing a unique code to each lot indicating the specifications like farmer's code, lot number, date, month and year of procurement. Samples from each lot are tested and the results are recorded. These samples are kept for one year to trace the farmer in case of export rejection or out brake of food born illness. Capacity of each plant varies between 3-5 tones of pepper per day.

4.3 Quality analysis

The following table reveals the values of quality parameters of pepper samples from different industries expressed in percentage.

Table 4.1 Volatile oil and oleoresin and moisture content of samples collected from various spice industries

Samples	Volatile Oil (%)	Oleoresin (%)	Moisture content (%)
Raw sample (black pepper) Wayanad Spices Processing Centre	2.00	11.95	10.50
Garbled pepper Wayanad Spices Processing Centre	1.90	11.80	10.40
Garbled pepper Palia Brothers Exporters	2.00	11.70	10.30
Garbled pepper Kuriakose Brothers Spices (P) Ltd	1.90	11.20	10.30
Garbled pepper St. Mary's Spices & Condiments	1.70	10.60	10.20
White pepper Wayanad Spices Processing Centre	1.50	9.75	10.35
Dehydrated green pepper St. Mary's Spices & Condiments	1.25	9.60	6.40

Table 4.2 Microbiological loads of different pepper samples collected from various spice Industries

Samples	Bacteria (10^6 cfu g^{-1})	Fungi (10^6 cfu g^{-1})	Yeast (10^6 cfu g^{-1})
Raw sample (black pepper) Wayanad Spices Processing Centre	1.0	Nil	Nil
Garbled pepper Wayanad Spices Processing Centre	Nil	Nil	Nil
Garbled pepper Palia Brothers Exporters	1.0	Nil	Nil
Garbled pepper Kuriakose Brothers Spices (P) Ltd	5.0	Nil	Nil
Garbled pepper St. Mary's Spices & Condiments	5.0	Nil	Nil
White pepper Wayanad Spices Processing Centre	1.0	Nil	Nil
Dehydrated green pepper St. Mary's Spices & Condiments	4.0	Nil	Nil

The various quality parameters like moisture content, oleoresin, volatile oil were determined and the results revealed that they were in agreement with the quality specification for export specified by BS 7087-1:1995 (http://www.standardsdirect.org/ standards.html)

The outcome of microbiological analysis reinforces the quality aspects of almost all the pepper products in different industries surveyed. Presence of fungal and actinomycetes were found negligible in all the industries. Occurrence of bacteria was within permissible value (10^6cfu/g, http://www.indianspices.com/html/s1490qua.htm) for Wayanad Spices Processing Centre and Palia Brothers Exporters. The industries vulnerable to bacterial contamination includes Kuriakose Brothers Spices (P) Ltd (garbled pepper) and St. Mary's Spices & Condiments (garbled pepper, dehydrated green pepper). The bacterial contagion was owing to improper handling and increased human intrusion during processing.

As recommended by HACCP protocol the use of good quality water, good hygienic and sanitation practices, proper storage facility, smooth and well drainable floorings, minimizing the contact with the external atmosphere, automation of the processes contribute to the reduced bacterial interference on the quality of exported pepper.

4.4 Development of HACCP protocol for black pepper

Most of the industries did not follow a straight processing line. This adversely affected the quality to a certain extend due to increase human handling in processing centres.

Prior to development of HACCP protocol worksheets were prepared considering each unit operations in the process line. This worksheet formed the basis for the development of new process line. The worksheet prepared for black pepper industry is given in Table 4.1 and that for other products are specified in Appendix VII, VIII and IX.

The HACCP analysis proposed three Critical Control Points in the processing line (Table 4.2). Of these CCP1 (Mycotoxin) and CCP2 (Chemical residue) are in the reception stage and CCP3 (metal hazard) in the metal detection stage. The processing industry is utilized neither magnetic separators for removal of iron particles from the raw spices, nor sterilization procedures to reduce the bacterial load to safe limit ($<10^6$ cfu). The gap analysis suggested some changes in the processing line as well as human handling. Magnetic separator and metal detector are essential to those industries who are involved in export.

The modified flow diagram prepared for the safe production of black pepper is shown in Fig. 4.1. Modifications include the incorporation of a) bucket elevators for automation of process b) sterilizing unit to reduce microbiological contamination c) metal detector to remove metals incorporated with the product during processing d) packing unit to avoid human intervention in packing as depicted in worksheet shown in Table 4.3.

The analysis of the HACCP worksheet (Appendix VII) for the production of safe white pepper suggests the use of colour sorter for effective separation of white pepper berries, in addition to sterilizing unit, metal detector and packing unit. The modified flow diagram is as depicted in Fig. 4.2.

The HACCP worksheet for safe dehydrated green pepper (Appendix VIII) and for safe pepper in brine (Appendix IX) revealed the requirement for bucket elevators, sterilizing unit, metal detector and packing unit. These modifications are made in the flow diagram as shown in Fig 4.3 and Fig 4.4 respectively.

Finally modifications incorporating GMP and HACCP principles that are described above are built-in the layout and process line of various industries surveyed as exposed in Fig: 4.5, 4.6, 4.7 and 4.8 respectively.

Table 4.3 HACCP HAZARD ANALYSIS WORKSHEET FOR BLACK PEPPER INDUSTRY

Process step	**Potential hazard**	**Does the hazard need to be in HACCP plan .Why?**	**Can this be controlled by prerequisite programme?**	**Preventive or remedial measures**	**Is this a CCP? (Y/N)**
Reception	Physical - Mislabeled product	No, although incoming spice items may arrive at the facility with physical contaminants there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Corrective actions from suppliers and trailer inspections	No
	Chemical - Pesticide, mycotoxin	Yes, Mycotoxins have been associated with black pepper in which there is improper storage or handling	Yes	Vendor selection and evaluation. Supplier certificates of analysis	Yes **CCP 1**
	Microbiological - *Salmonella spp.*	Yes, although incoming spice items may arrive at the facility with microbiological contaminants there are microbial reduction steps further down the process to eliminate or reduce the threat to an acceptable level	Yes	GMP's, SSOP's, microbial reduction process	Yes **CCP 2**
Storage	Sanitation chemicals, contamination by pests	No, good prerequisite programs offer control	Yes	Master sanitation programs, GMP's and pest control program	No

	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, pest control, warehouse sanitation programs & chemical control program	No
Cleaning & grading	Physical	No, this step is to reduce or to eliminate physical contaminants	Yes	Preventative maintenance program, GMP's, Self-Inspection Programs, Quality testing	No
	Chemical	No	Yes	GMP's, SSOP's and allergen control programs	No
	Microbiological	No	Yes	GMP's, SSOP's, microbial reduction process	No
Metal detection	Physical - metal	Yes, Choking and/or laceration hazard	No	Detection at preset levels - metal detector	Yes **CCP 3**
	Chemical	No	Yes		No
	Microbiological	No	Yes		No
Packaging	Physical	No, The opportunity for additional contaminations are limited	Yes	Preventative maintenance program, GMP's, Self Inspection Programs	No
	Chemical	No, The opportunity for additional contaminations are limited	Yes	GMP's, allergen control programs	No
	Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, SSOP's, microbial reduction process	No

CRITICAL CONTROL POINT ANALYSIS

CCP	Process step	Hazard	Control measure	Can this be controlled by prerequisite program	Monitoring procedure	Corrective action
CCP1	Reception	Mycotoxin	No effective technique	Yes (proper handling and storage)	Vendor/farmer selection and evaluation, Sampling &analysis	Avoid entry to the process lines
CCP2		Chemical residue	GAP and GMP	Yes (by GAP, GMP)		
CCP3	Metal detection	Metal	Metal detector	No	On-line inspection	Hold and review

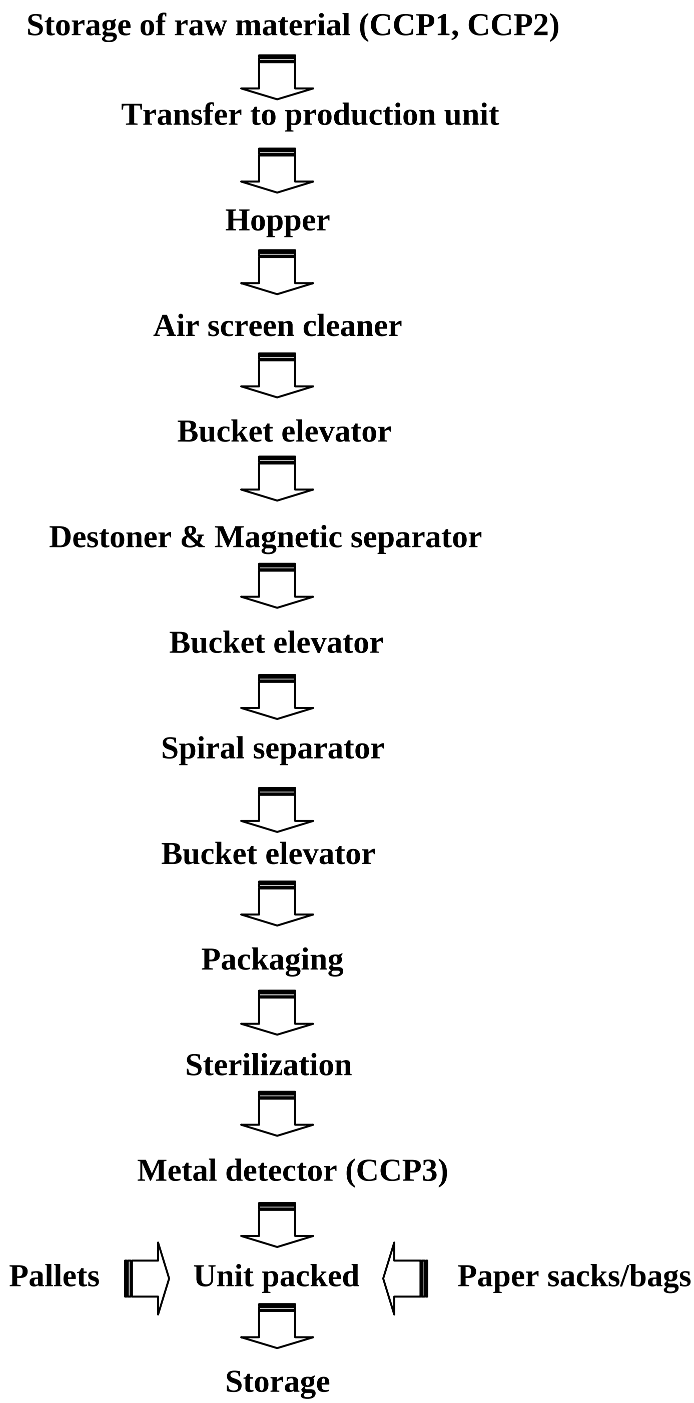


Fig. 4.1 Modified flow chart for the production of safe black pepper

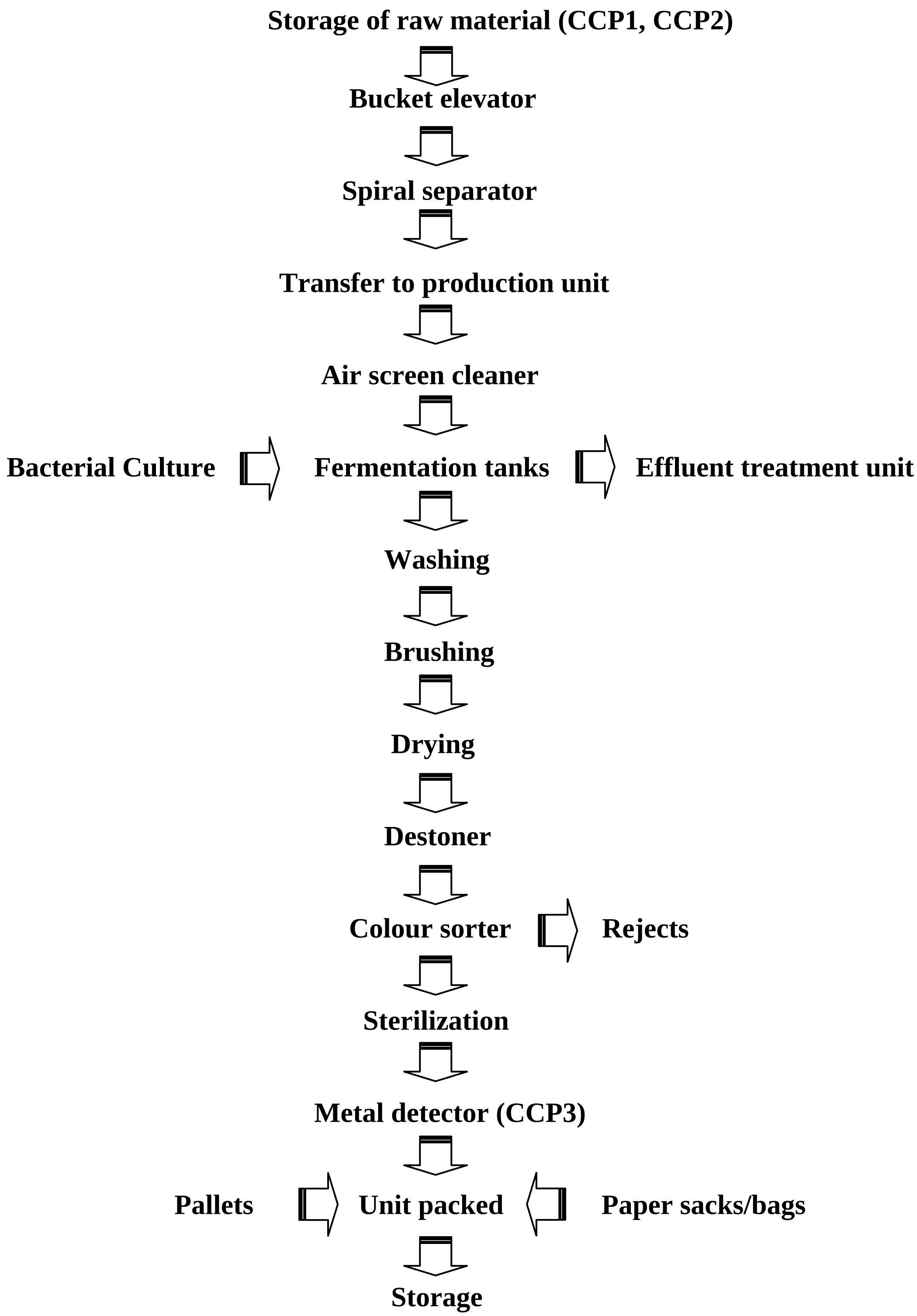


Fig. 4.2 Modified flow chart for the production of safe white pepper

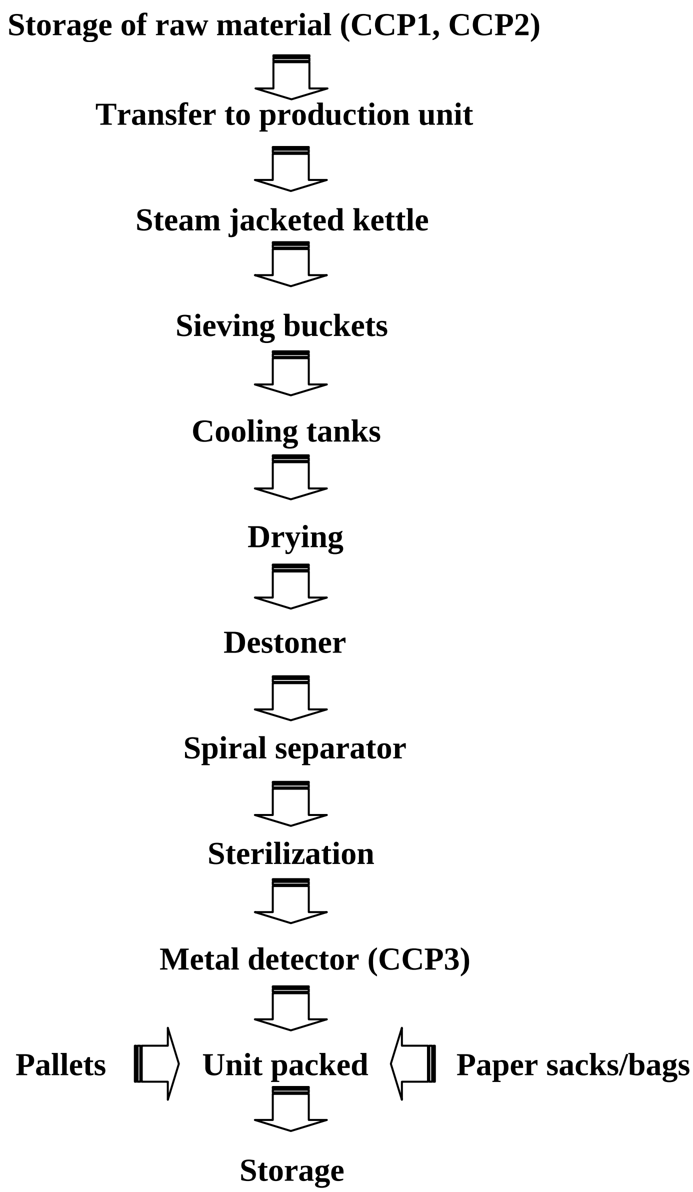


Fig. 4.3 Modified flow chart for the production of safe dehydrated green pepper

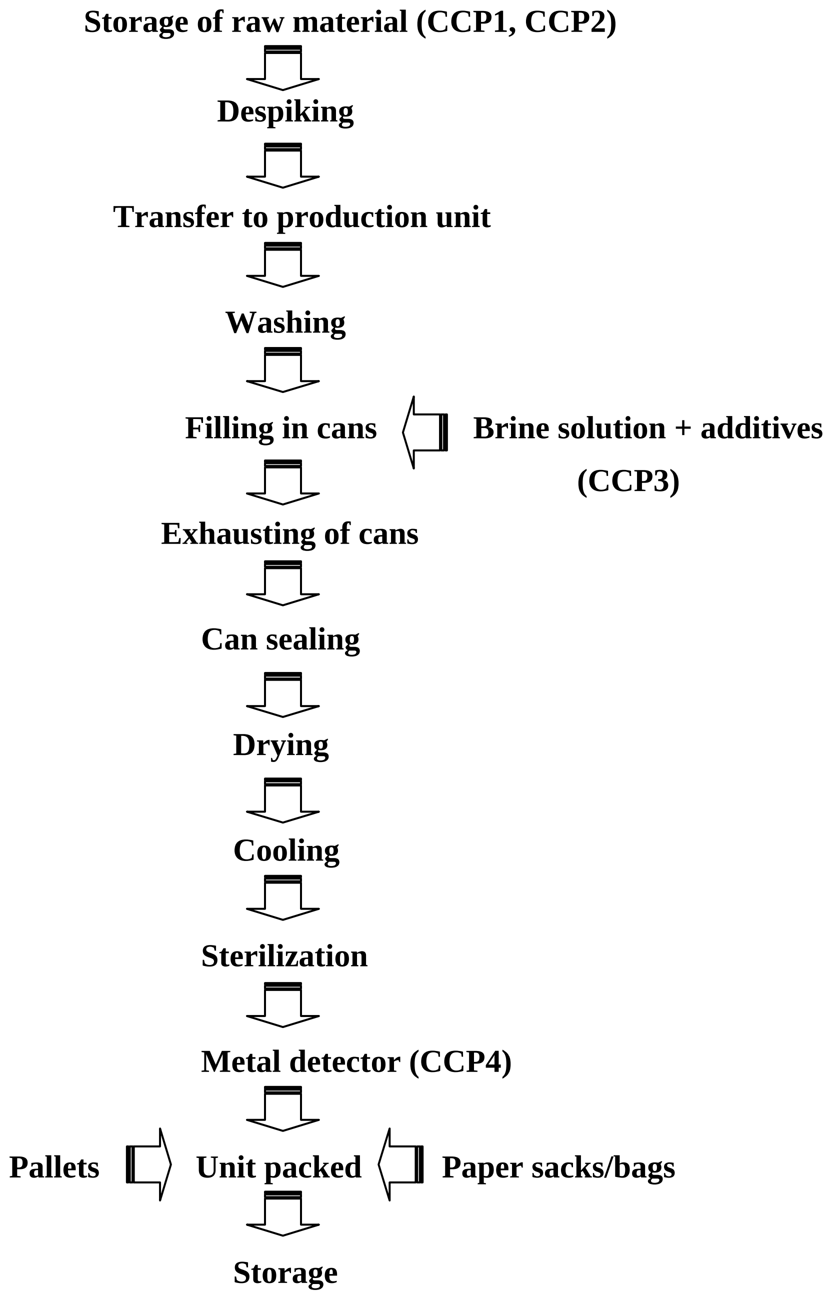
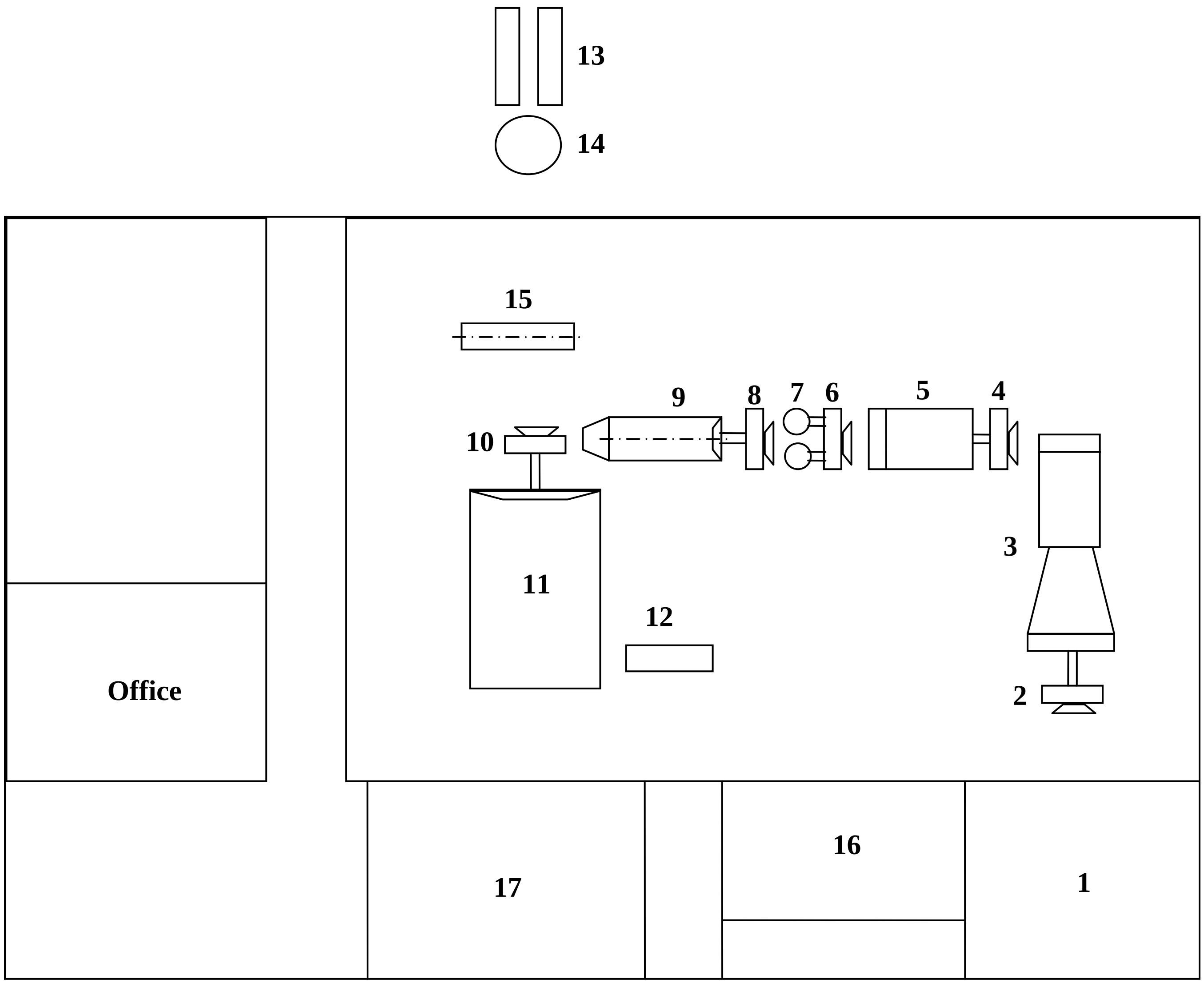
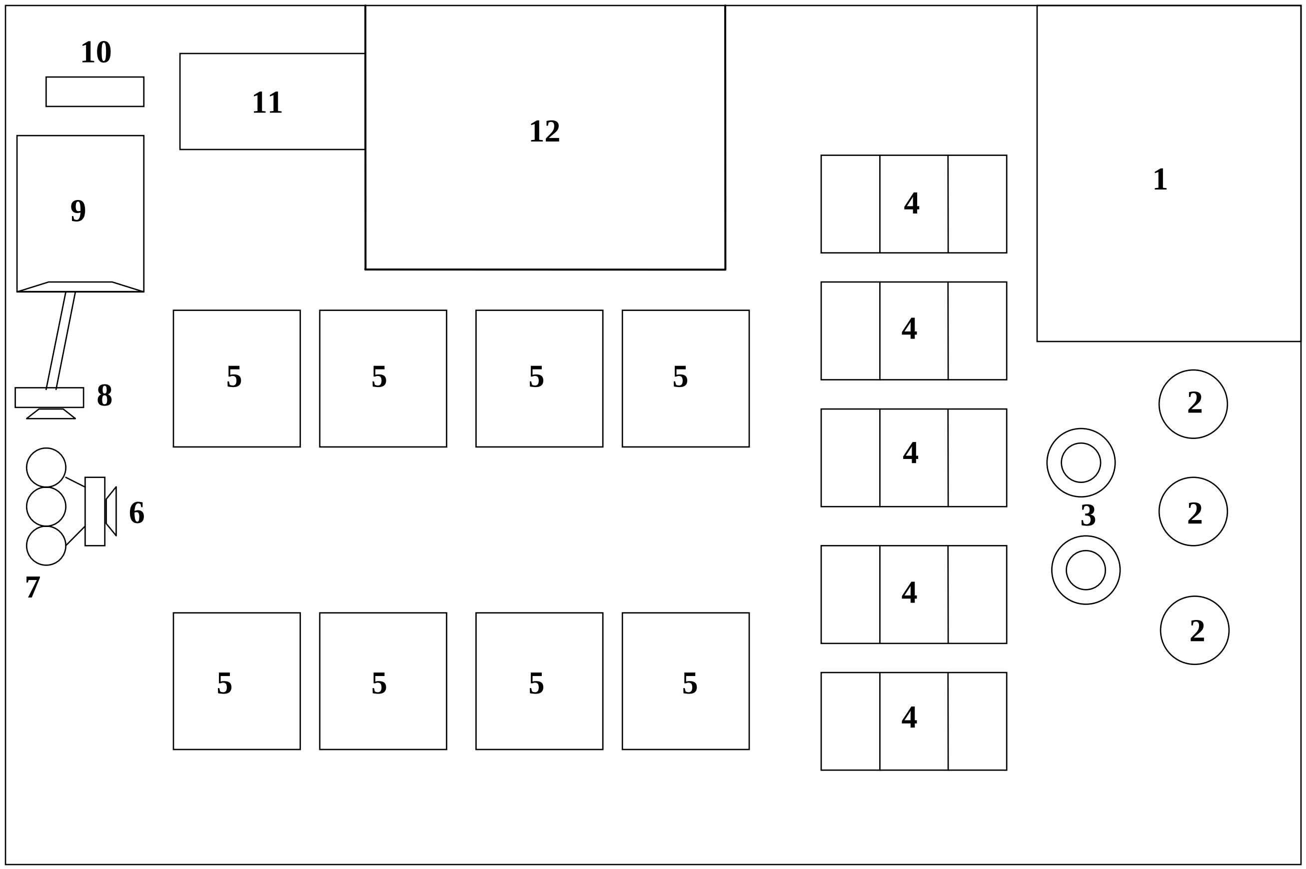


Fig. 4.4 Modified flow chart for the production of safe pepper in brine



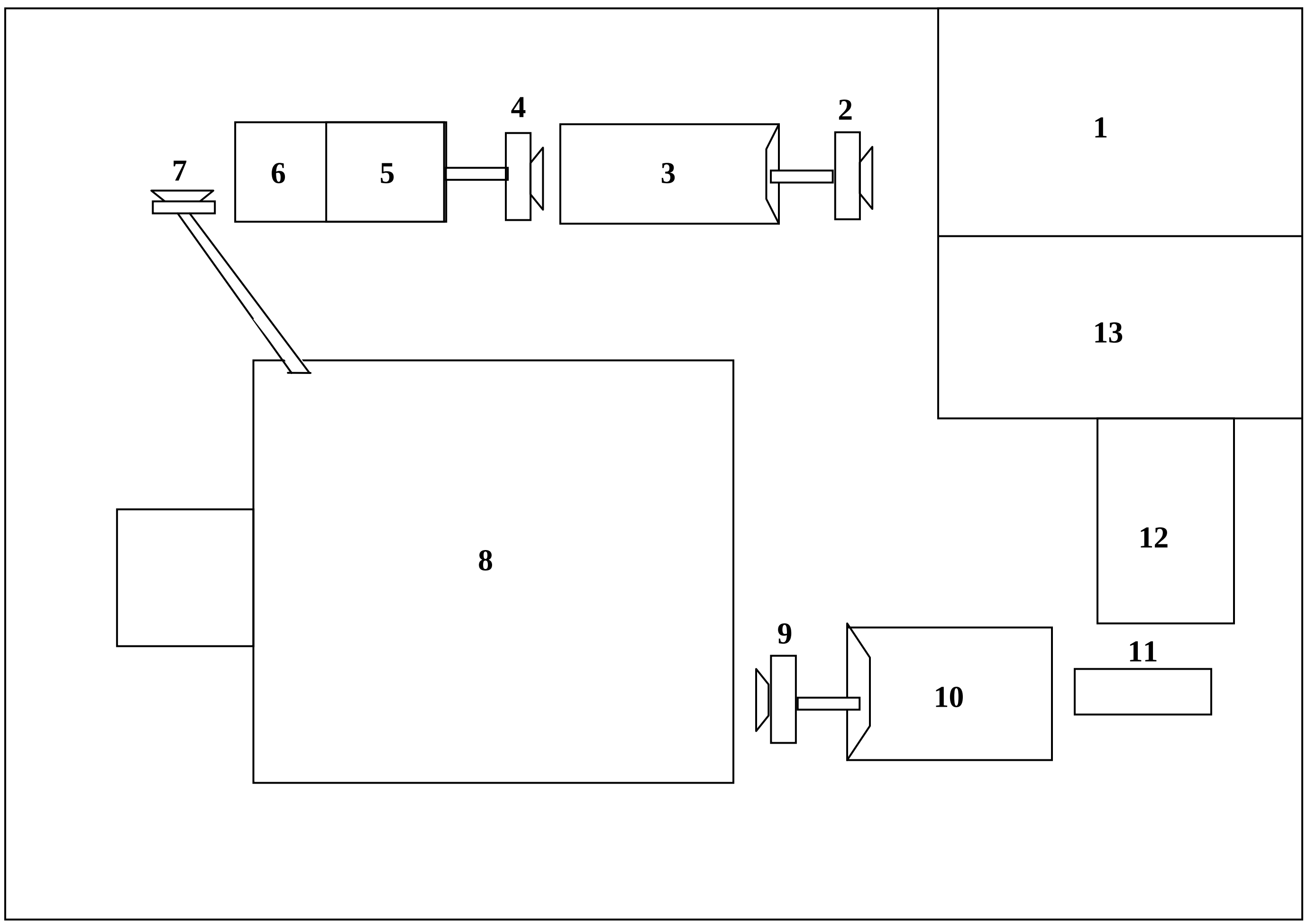
1. Raw material store
2. Bucket elevator
3. Destoner
4. Bucket elevator
5. Magnetic separator
6. Bucket elevator
7. Spiral separator
8. Bucket elevator
9. Brushing machine
10. Bucket elevator
11. Sterilizing unit
12. Metal detector
13. Fermentation tanks
14. Mother tank
15. Pulper
16. Packing
17. Product store

Fig. 4.5 Modified plant layout [Wayanad Spices Processing Centre]



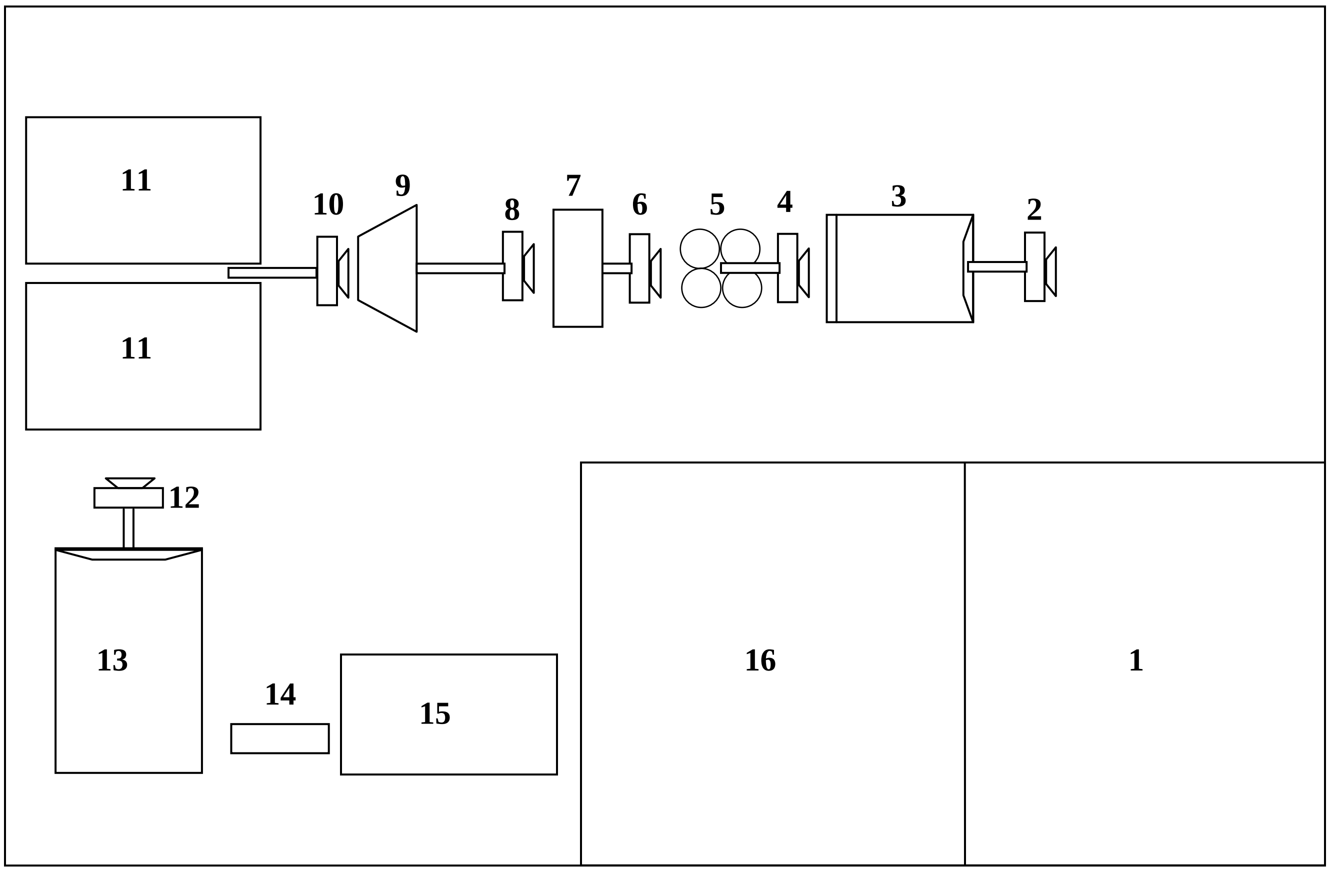
1. Raw material store
2. Steam jacketed kettle
3. Sieving bucket
4. Cooling tank
5. Drier
6. Bucket elevator
7. Spiral separator
8. Bucket elevator
9. Sterilizing unit
10. Metal detector
11. Packing unit
12. Product store

Fig. 4.6 Modified plant layout [St. Mary's Spices & Condiments]



1. Raw material store
2. Bucket elevator
3. Destoner
4. Bucket elevator
5. Specific gravity separator
6. Grader
7. Bucket elevator
8. Drier
9. Bucket elevator
10. Sterilizing unit
11. Metal detector
12. Packing unit
13. Product store

Fig. 4.7 Modified plant layout [Palia Brothers Manufacturers and Exporters]



1. Raw material store
2. Bucket elevator
3. Destoner
4. Bucket elevator
5. Spiral separator
6. Bucket elevator
7. Grader
8. Bucket elevator
9. Garbling
10. Bucket elevator
11. Drier
12. Bucket elevator
13. Sterilizing unit
14. Metal detector
15. Packing unit
16. Product store

Fig. 4.7 Modified plant layout [Kuriakose Brothers Spices (P) Ltd.]

SUMMARY AND CONCLUSION

CHAPTER V
SUMMARY AND CONCLUSION

Pepper is the most important spice traded internationally, which is extensively cultivated in Kerala. Assurance in the superior quality of the product exported is essential for having excellent market value. This study depicts the use of good manufacturing practices (GMPs) and management techniques like Hazard Analysis Critical Control Points (HACCP) to trim down human intervention for safe final products.

To ensure the quality of pepper exported, a detailed survey was conducted in Wayanad district which contributes a major share in pepper export from Kerala. The survey was mainly concentrated on probing GAP and GMP principles after visiting farmers and industries in four different regions namely Mananthavady, Pulpally, Sultan Bathery and Ambalavayal. The different industries comprised of Wayanad Spices Processing Centre, St. Mary's Spices and Condiments**,** Palia Brothers Manufacturers and Exporters and Kuriakose Brothers Spices (P) Ltd. Samples from each industry were taken for examining its quality.

The analysis revealed that the quality parameters of the products namely volatile oil, oleoresin, and moisture content were satisfactory. The microbiological analysis using Serial Dilution Test revealed microbial contamination due to improper handling and storage practices. Suggestions for modifying the process lines by incorporating GMP and HACCP principles and there by reducing human interventions, for improving the quality of the product was the outcome of this study.

Harvesting and off farm processing are important operations, on which the quality of the final products depends. Cleanliness should be ensured at every stage of post harvest handling. Harvesting at the correct stage, processing and drying under hygienic conditions are essential prerequisite for producing attractive clean products. Mechanization of the various operations and the incorporation of safety management principles can surely go a long way in achieving the final goal of high quality products.

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CHAPTER VI

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APPENDICES

APPENDIX – I

Observation Table [Volatile Oil]

Samples	Volatile oil (%)			
	I	II	III	Mean
Raw sample (black pepper) Wayanad Spices Processing Centre	2.00	1.90	2.10	2.00
Garbled pepper Wayanad Spices Processing Centre	1.80	1.90	2.00	1.90
Garbled pepper Palia Brothers Exporters	2.00	2.00	2.00	2.00
Garbled pepper Kuriakose Brothers Spices (P) Ltd	1.85	1.95	1.90	1.90
Garbled pepper St. Mary's Spices & Condiments	1.80	1.60	1.70	1.70
White pepper Wayanad Spices Processing Centre	1.35	1.55	1.60	1.50
Dehydrated green pepper St. Mary's Spices & Condiments	1.40	1.20	1.15	1.25

APPENDIX – II

Observation Table [Oleoresin]

Samples	Oleoresin (%)			
	I	II	III	Mean
Raw sample (black pepper) Wayanad Spices Processing Centre	11.90	11.95	12..00	11.95
Garbled pepper Wayanad Spices Processing Centre	11.80	11.70	11.90	11.80
Garbled pepper Palia Brothers Exporters	11.65	11.75	11.70	11.70
Garbled pepper Kuriakose Brothers Spices (P) Ltd	11.10.	11.10	11.40	11.20
Garbled pepper St. Mary's Spices & Condiments	10.50	10.55	10.75	10.60
White pepper Wayanad Spices Processing Centre	9.55	9.70	10.00	9.75
Dehydrated green pepper St. Mary's Spices & Condiments	9.75	9.55	9.50	9.60

APPENDIX – III

Observation Table [Moisture Content]

Samples	Moisture content (%)			
	I	II	III	Mean
Raw sample (black pepper) Wayanad Spices Processing Centre	10.4	10.60	10.50	10.50
Garbled pepper Wayanad Spices Processing Centre	10.35	10.50	10.35	10.40
Garbled pepper Palia Brothers Exporters	10.40	10.35	10.15	10.30
Garbled pepper Kuriakose Brothers Spices (P) Ltd	10.30	10.35	10.25	10.30
Garbled pepper St. Mary's Spices & Condiments	10.25	10.18	10.17	10.20
White pepper Wayanad Spices Processing Centre	10.40	10.35	10.30	10.35
Dehydrated green pepper St. Mary's Spices & Condiments	6.45	6.30	6.45	6.4

APPENDIX – IV

Observation Table [Bacteria]

Samples	Bacteria (10^6 cfu/g)			
	I	**II**	**III**	**Mean**
Raw sample (black pepper) Wayanad Spices Processing Centre	1.0	Nil	2.0	1.0
Garbled pepper Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Garbled pepper Palia Brothers Exporters	1.0	1.0	1.0	1.0
Garbled pepper Kuriakose Brothers Spices (P) Ltd	4.0	6.0	5.0	5.0
Garbled pepper St. Mary's Spices & Condiments	4.0	5.0	5.0	5.0
White pepper Wayanad Spices Processing Centre	2.0	1.0	Nil	1.0
Dehydrated green pepper St. Mary's Spices & Condiments	5.0	3.0	4.0	4.0

APPENDIX – V

Observation Table [Fungus]

Samples	Fungus (10^3 cfu/g)			
	I	II	III	Mean
Raw sample (black pepper) Wayanad Spices Processing Centre	Nil	1.0	Nil	Nil
Garbled pepper Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Garbled pepper Palia Brothers Exporters	Nil	Nil	1.0	Nil
Garbled pepper Kuriakose Brothers Spices (P) Ltd	1.0	Nil	Nil	Nil
Garbled pepper St. Mary's Spices & Condiments	Nil	Nil	Nil	Nil
White pepper Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Dehydrated green pepper St. Mary's Spices & Condiments	Nil	Nil	1.0	Nil

APPENDIX – VI

Observation Table [Actinomycetes]

Samples	Actinomycetes (10^5 cfu/g)			
	I	II	III	Mean
Raw sample (black pepper) Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Garbled pepper Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Garbled pepper Palia Brothers Exporters	Nil	Nil	Nil	Nil
Garbled pepper Kuriakose Brothers Spices (P) Ltd	Nil	Nil	Nil	Nil
Garbled pepper St. Mary's Spices & Condiments	Nil	Nil	Nil	Nil
White pepper Wayanad Spices Processing Centre	Nil	Nil	Nil	Nil
Dehydrated green pepper St. Mary's Spices & Condiments	Nil	Nil	Nil	Nil

APPENDIX – VII
HACCP HAZARD ANALYSIS WORKSHEET FOR WHITE PEPPER PRODUCTION

Process step	**Potential hazard**	**Does the hazard need to be in HACCP plan .Why?**	**Can this be controlled by prerequisite programme?**	**Preventive or remedial measures**	**Is this a CCP? (Y/N)**
Reception	Physical - Mislabeled product	No, although incoming spice items may arrive at the facility with physical contaminants, there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Corrective actions from suppliers and trailer inspections	No
	Chemical - Pesticide, mycotoxin	Yes, Mycotoxins have been associated with black pepper in which there is improper storage or handling	Yes	Vendor selection and evaluation. Supplier certificates of analysis	Yes **CCP 1**
	Microbiological - Salmonella *spp.*	Yes, although incoming spice items may arrive at the facility with microbiological contaminants there are microbial reduction steps further down the process to eliminate or reduce the threat to an acceptable level	Yes	GMP's, SSOP's, microbial reduction process	Yes **CCP 2**
Storage	Chemical- Sanitation chemicals	No, good prerequisite programs offer control	Yes	Master sanitation programs	No
	Microbiological - Contamination by pests	No, good prerequisite programs offer control	Yes	GMP's and pest control program	No

	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, pest control, warehouse sanitation programs & chemical control program	No
Cleaning & grading	Physical	No, this step is to reduce or to eliminate physical contaminants	Yes	Preventative maintenance program, GMP's, Self-Inspection Programs, Quality testing	No
	Chemical	No	Yes	GMP's, SSOP's and allergen control programs	No
	Microbiological	No	Yes	GMP's, SSOP's, microbial reduction process	No
Fermentation tanks	Physical Chemical Microbiological	No, there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	GMP's, Self-Inspection Programs, Quality testing, allergen control programs	No
Drying	Physical Chemical Microbiological	No, there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Preventative maintenance program, GMP's, Self-Inspection Programs, Quality testing	No
Metal detection	Physical - metal	Yes, Choking and/or laceration hazard	No	metal detector (1-1.5mm for ferrous and 2-2.5mm for non ferrous)	Yes **CCP 3**
	Chemical	No	Yes		No
	Microbiological	No	Yes		No

Packaging	Physical	No, The opportunity for additional contaminations are limited	Yes	Preventative maintenance program, GMP's, Self Inspection Programs	No
	Chemical	No, The opportunity for additional contaminations are limited	Yes	GMP's, allergen control programs	No
	Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, SSOP's, microbial reduction process	No

CRITICAL CONTROL POINT ANALYSIS

CCP	Process step	Hazard	Control measure	Can this be controlled by prerequisite program	Monitoring procedure	Corrective action
CCP1	Reception	Mycotoxin	No effective technique	Yes (proper handling and storage)	Vendor/farmer selection and evaluation, Sampling &analysis	Avoid entry to the process lines
CCP2		Chemical residue	GAP and GMP	Yes (By GAP, GMP)		
CCP3	Metal detection	Metal	Metal detector	No	On-line inspection metal detector (1-1.5mm for ferrous and 2-2.5mm for non ferrous)	Hold and review

APPENDIX - VIII
HACCP HAZARD ANALYSIS WORKSHEET FOR DEHYDRATED GREEN PEPPER PRODUCTION

Process step	**Potential hazard**	**Does the hazard need to be in HACCP plan .Why?**	**Can this be controlled by prerequisite programme?**	**Preventive or remedial measures**	**Is this a CCP? (Y/N)**
Reception	Physical - Mislabeled product	No, although incoming spice items may arrive at the facility with physical contaminants there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Corrective actions from suppliers and trailer inspections	No
	Chemical - Pesticide, mycotoxin	Yes, Mycotoxins have been associated with black pepper in which there is improper storage or handling	Yes	Vendor selection and evaluation. Supplier certificates of analysis	Yes **CCP 1**
	Microbiological - Salmonella *spp.*	Yes, although incoming spice items may arrive at the facility with microbiological contaminants there are microbial reduction steps further down the process to eliminate or reduce the threat to an acceptable level	Yes	GMP's, SSOP's, microbial reduction process	Yes **CCP 2**
Storage	Chemical- Sanitation chemicals	No, good prerequisite programs offer control	Yes	Master sanitation programs	No
	Microbiological - Contamination by pests	No, good prerequisite programs offer control	Yes	GMP's and pest control program	No

	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, pest control, warehouse sanitation programs & chemical control program	No
Cleaning & grading	Physical	No, this step is to reduce or to eliminate physical contaminants	Yes	Preventative maintenance program, GMP's, Self-Inspection Programs, Quality testing	No
	Chemical	No	Yes	GMP's, SSOP's and allergen control programs	No
	Microbiological	No	Yes	GMP's, SSOP's, microbial reduction process	No
Steaming	Physical Chemical Microbiological	No,The opportunity for additional contaminations are limited	Yes	Self-Inspection Programs, Quality testing	No
Cooling	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	Water quality testing. Preventative maintenance program, GMP's	No
Metal detection	Physical - metal	Yes, Choking and/or laceration hazard	No	Detection at preset levels - metal detector	Yes **CCP 3**
	Chemical	No	Yes		No
	Microbiological	No	Yes		No
Packaging	Physical	No, The opportunity for additional contaminations are limited	Yes	Preventative maintenance program, GMP's, Self Inspection Programs	No

	Chemical	No, The opportunity for additional contaminations are limited	Yes	GMP’s, allergen control programs	No
	Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP’s, SSOP’s, microbial reduction process	No

CRITICAL CONTROL POINT ANALYSIS

CCP	**Process step**	**Hazard**	**Control measure**	**Can this be controlled by prerequisite program**	**Monitoring procedure**	**Corrective action**
CCP1	Reception	Mycotoxin	No effective technique	Yes (proper handling and storage)	Vendor/farmer selection and evaluation, Sampling &analysis	Avoid entry to the process lines
CCP2		Chemical residue	GAP and GMP	Yes (By GAP, GMP)		
CCP3	Metal detection	Metal	Metal detector	No	On-line inspection	Hold and review

APPENDIX – IX

HACCP HAZARD ANALYSIS WORKSHEET FOR PEPPER IN BRINE PRODUCTION

Process step	**Potential hazard**	**Does the hazard need to be in HACCP plan .Why?**	**Can this be controlled by prerequisite programme?**	**Preventive or remedial measures**	**Is this a CCP? (Y/N)**
Reception	Physical - Mislabeled product	No, although incoming spice items may arrive at the facility with physical contaminants there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Corrective actions from suppliers and trailer inspections	No
	Chemical - Pesticide, mycotoxin	Yes, Mycotoxins have been associated with black pepper in which there is improper storage or handling	Yes	Vendor selection and evaluation. Supplier certificates of analysis	Yes **CCP 1**
	Microbiological - Salmonella *spp.*	Yes, although incoming spice items may arrive at the facility with microbiological contaminants there are microbial reduction steps further down the process to eliminate or reduce the threat to an acceptable level	Yes	GMP's, SSOP's, microbial reduction process	Yes **CCP 2**
Storage	Chemical-Sanitation chemicals	No, good prerequisite programs offer control	Yes	Master sanitation programs	No
	Microbiological - Contamination by pests	No, good prerequisite programs offer control	Yes	GMP's and pest control program	No

	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP’s, pest control, warehouse sanitation programs & chemical control program	No
Cleaning & grading	Physical	No, this step is to reduce or to eliminate physical contaminants	Yes	Preventative maintenance program, GMP’s, Self-Inspection Programs, Quality testing	No
	Chemical	No	Yes	GMP’s, SSOP’s and allergen control programs	No
	Microbiological	No	Yes	GMP’s, SSOP’s, microbial reduction process	No
Filling	Physical Chemical Microbiological	Yes ,The opportunity for additional contaminations through polluted water	No	GMP’s, SSOP’s,Self-Inspection Programs, Quality testing	Yes **CCP3**
Drying	Physical Chemical Microbiological	No, there are cleaning steps further down the process to eliminate or reduce these down to an acceptable level.	Yes	Preventative maintenance program, GMP’s, Self-Inspection Programs, Quality testing	No
Cooling	Physical Chemical Microbiological	No, The opportunity for additional contaminations are limited	Yes	Water quality testing. Preventative maintenance program, GMP’s	No
Metal detection	Physical - metal	Yes, Choking and/or laceration hazard	No	Detection at preset levels - metal detector	Yes **CCP 4**
	Chemical	No	Yes		No
	Microbiological	No	Yes		No

Packaging	Physical	No, The opportunity for additional contaminations are limited	Yes	Preventative maintenance program, GMP's, Self Inspection Programs	No
	Chemical	No, The opportunity for additional contaminations are limited	Yes	GMP's, allergen control programs	No
	Microbiological	No, The opportunity for additional contaminations are limited	Yes	GMP's, SSOP's, microbial reduction process	No

CRITICAL CONTROL POINT ANALYSIS

CCP	Process step	Hazard	Control measure	Can this be controlled by prerequisite program	Monitoring procedure	Corrective action
CCP1	Reception	Mycotoxin	No effective technique	Yes (proper handling and storage)	Vendor or farmer selection and evaluation, Sampling &analysis	Avoid entry to the process lines
CCP2		Chemical residue	GAP and GMP	Yes (By GAP, GMP)		
CCP3	Metal detection	Metal	Metal detector	No	On-line inspection	Hold and review

DEVELOPMENT OF GMP AND HACCP PROTOCOL FOR PEPPER INDUSTRY

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ABSTRACT OF THE PROJECT REPORT

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requirement for the degree

Bachelor of Technology
In
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Kerala Agricultural University

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ABSTRACT

Pepper, commonly called as “King of Spices” has been one of the most ancient commodities of the spice trade. India being the major producer of world’s pepper, it is necessary to exercise a strict check and control over the qualities of pepper to be exported. The present study reports the results of the survey conducted for assessing the quality of the black pepper in Wayanad district, which is the major exporter of black pepper in Kerala. The survey conducted in four major exporting spice industries and the analysis using total plate count revealed microbial contamination due to improper handling and storage practices. The quality of the processed black pepper can be improved with the help of proper implementation of food safety and management systems like hazard analysis and critical control points (HACCP). The study proposed a new HACCP protocol for these industries by modifying the process lines and human interventions for maintaining the quality of final products.