STUDIES ON DEVELOPMENT OF BOTTLED HERBAL PORRIDGE (KOLAKENDA) OF WEL-PENELA (*Cardiospermum halicacabum*) STORED UNDER AMBIENT TEMPERATURE

By

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(02/AS/A/046)

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DECLARATION

This work described in this thesis was carried out by me at the Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, under the supervision of Mr.Lasantha Ratnayake and Mrs.Rasangi Sabaragamuwa. A report on this has not been submitted to another university for another degree.

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AFFECTIONATELY DEDICATED
TO
MY LOVING PARENTS

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ABSTRACT

Introduction of ready to serve bottled herbal porridge (kolakenda) to the non-competitive market with extracts of Wel-penela (*Cardiospermum halicacabum*) in rice and coconut-milk medium is profitable. Shelf life evaluation and sensory evaluation is a must before introducing this type of product. This study was conducted to add value to a bottled herbal porridge (kolakenda) of Wel-penela (*Cardiospermum halicacabum*) stored under ambient temperature and to evaluate shelf life for two weeks.

The extracts were obtained by cutting, blending and squeezing the mass of Wel-penela with water, ground rice was boiled with chopped garlic about 20-30 minutes until it got soften, prepared coconut milk and herbal extract were added to the boiled ingredients, the mixture was re-boiled for another 5-10 minutes and salt was added. The preservatives (citric acid, ascorbic acid, Sodium Benzoate (SB) and Sodium Meta-bisulphite (SMS) were added after the mixture was taken out of the flame. The prepared porridge in the liquid form was poured in to jars immediately and was exhausted in a hot water bath until the center of the liquid was 82°C and was kept about 10 minutes. Then it was sealed immediately and the jars were cooked at 85°C for 25 minutes. After cooling and labeling the jars were stored at ambient temperature.

Determination of best bottled herbal porridge was done using citric acid, ascorbic acid and acid control with SB and SMS. Among them citric acid treated samples presented best sensory appeal according to the sensory evaluation panel. Thus herbal porridge with citric acid, SB and SMS was selected as best type of product. To evaluate the shelf life, pH and Total Soluble Solids (TSS) were measured and microbial tests were done after 14 days of storage at ambient temperature. Finally sensory evaluation was done to evaluate the difference of bottled herbal porridge after storing two weeks and immediately prepared herbal porridge without any preservatives.

The study revealed that the best type of bottled herbal porridge was one which contains citric acid, SB and SMS as preservatives. pH (5.2) and TSS (3) were constant during the study period. Bottled herbal porridge was microbiologically safe and it is 8.2×10^2 for bacteria, 5×10^1 for yeast and molds and no Coliforms were detected after 14 days and providing an aseptic sterile environment will be reduce contamination much lower. The results of sensory evaluation test revealed that there is no significant difference in between bottled herbal porridge after storing two weeks and immediately prepared herbal porridge without any preservatives.

CONTENTS

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

LIST OF ABBREVIATIONS

MOH	Medical Office of Health
SB	Sodium Benzoate
SMS	Sodium Metabisulfite
TSS	Total Soluble Solids
TPC	Total Plate Count
App.	Appendix
min.	Minutes
SLS	Sri Lanka Standard
et al.	And others
ppm	Parts per million
No.	Number
Fig.	Figure
QA	Quality Assurance
QC	Quality Control

CHAPTER 01

INTRODUCTION

1.1 Introduction

"Kolakenda", a traditional Sri Lankan ayurvedic preparation, which is very popular as a health food and forms an important part of the breakfast as a common day-starter of most rural Sri Lankans.

This porridge is made mainly of juice of herbs, rice and coconut milk which are generally considered to be of high medicinal value and high nutritional value. It gives high energy content, low viscosity with an acceptable thickness, balanced protein containing all essential amino acids, Vitamin A, B, D, minerals such as iron, folic acid, calcium, no anti nutritional components and gives pleasant taste (Altes et al 2000).

The market sales of ready-to-consume natural herbal porridge have grown rapidly in recent decades as a result of changes in consumer attitudes. According to the busy life style of people, they don't have sufficient time to cut green leaves and extract juice by blending, scrape coconuts and blend and cook with rice. So ready to serve natural herbal porridge is a very convenient product for them.

Ayurveda is a complete science of health and it aims to protect the health of the healthy and to alleviate disorders in the diseased. In Sri Lanka, many herbal plant varieties are utilized in manufacturing of herbal porridges such as,

Gotukola (*Centella asiatica*) - For healthy eyes and lungs

Wel-penela (*Cardiospermum halicacabum*) - Remedy for rheumatism

Hathawariya (*Asparagus falcatus*) - Purifies blood and rejuvenates

Iramusu (*Hemidesmus indicus*) - Purifies blood

Polpala (*Aerva lanata*) - For urinary disorders

Mukunuwenna (*Alternanthera sessilis*) - For soothing eyes, skin and hair

and to be taken for breakfast with a piece of "jaggery".

The following diagram shows the method of home-made herbal porridge.

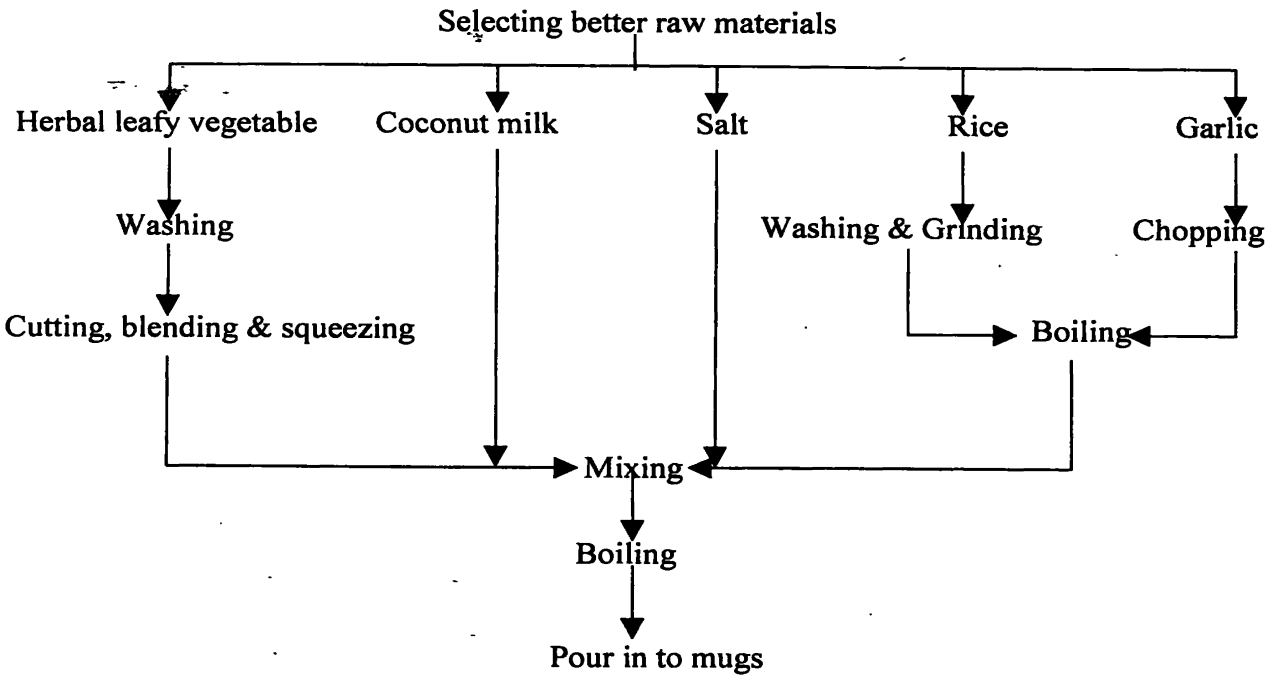

Fig. 1.1 Method of home-made herbal porridge

In Sri Lanka, Studies on Gelled, Pasteurized and Sterilized Kolakenda (Ayurvedic Herbal Porridge) researches were conducted by Faculty of Applied Sciences of Department of Food Science and Technology in University of Sri Jayewardenepura (Kodikara 2005).

Owing to the global trend is instant and ready- to-consume food, this research is conducted to develop value added herbal porridge using Wel-penela packed in glass jars and stored under room temperature which can be sold in the market.

This bottle of herbal porridge provides many advantages to consumers, such as

- Easy to consume
- Adequate shelf life
- Made from local ingredients
- Affordable
- Safe microbial biological quality

1.1.1 The importance of introducing instant herbal foods to Sri Lankan people

- In Sri Lanka, only a limited number of green leaves are consumed by the people and hundreds of leafy vegetables are being neglected, but growing freely in their gardens and forests, while others are being discarded as weeds due to lack of knowledge of their nutrition and therapeutic value.
- In Sri Lanka, problems of malnutrition persist in particularly among women and pre-school children. Inadequate dietary intake and suffering from illness are two major causes of malnutrition. These problems include poor growth of children, high rates of

low birth weight, poor maternal malnutrition status and deficiencies of micronutrients. In long term adverse effect on productivity of the country by reduced work capacity among the population. So herbal porridge as a weaning food could be a one positive solution to the malnutrition problem of our children.

- Traditional food varieties can be effectively used as low cost food sources for low income groups of underdeveloped countries such as Sri Lanka. Introduction of low cost of food varieties to rural poor with low purchasing capacity affordable to the family budget and increasing the household food production to ensure the household food security.
- As a weaning food green leaves can be easily fortified to porridge to give high nutrition value. It has high palatability with high combination of rice and coconut and gives nutritional and therapeutic value. These herbs can easily grow in most areas of Sri Lanka.

1.2 Overall Objective

Development of value added herbal porridge using Wel-penela (*Cardiospermum halicacabum*) stored under ambient temperature.

1.3 Specific Objectives

1. To select best preservative to develop the best product
2. To evaluate sensory appeal to determine the best product
3. To evaluate the shelf life of the product

CHAPTER 02

LITERATURE REVIEW

2.1 Market Research

New product ideas, modifications of existing products or emulation of existing products produced by competitors should all respond to what the consumer wants. Ideally, market research determines what consumers want.

Basically there are two categories.

1. **Primary Market Research**

   Information is gathered directly from the public by surveys or questionnaires.

2. **Secondary Market Research**

   It uses existing published documents, surveys, reports and computer databases.

Market research is not just concerned with the launch of a new product, but should be a continuous process to allow the business to keep up to date with patterns and trends within the market place.

The basis of consumer research relies on the fact that there is overwhelming evidence that consumers behave in a standardized manner, therefore it is possible to examine the habits of a whole market by conducting tests upon small samples of the population.

Consumer research is concentrated around the behavior of the public, to establish, how, when and why a product was purchased but also how the product is actually used. To understand such behavior gives Marketing Managers an insight into how they might alter their strategy to enhance sales.

2.2 Product Development

Product development is the process of making a new or modified food product. The aim of product development is for a company to increase sales and remain competitive.

2.3 Wel-Penela (*Cardiospermum halicacabum*)

Scientific classification

Kingdom	: Plantae
Division	: Magnoliophyta
Class	: Magnoliopsida
Order	: Sapindales
Family	: Sapindaceae
Genus	: *Cardiospermum* L.

Species : *C. halicacabum* L.

2.3.1 Vernacular names

Sinhala	:	Penela, Wel-penela
Tamil	:	Kottavan
English	:	Balloon vine, Leaved heart pea, Love-in-a-puff, Winter cherry

2.3.2 Origin and geographic distribution

Originates from tropical America and it is a woody, perennial vine.

2.3.3 Plant Description

An annual, sub-scandent climber with a slender, strongly furrowed, glabrous stem and puberulous young parts.

Leaves : Alternate, petioles 5-7.5 cm long, spreading, furrowed, tapering at base, glabrous thin and flaccid.

Flowers : Irregular, white, very small, slender, bilateral symmetry with 4 unequal sepals and 4 petals.

Fruits : An inflated, 3-chambered, membranous, slender stalk, truncate at top, winged at the angles

Seeds : The aril heart shaped and white which is describe din the generic name *Cardiospermum* (Cardio – heart, sperma – seed).

C. halicacabum is propegated from seed where they are to be grown (Rajapaksha 1998).

2.3.4 Distribution

Grows in wet regions of India, Sri Lanka and Malacca.

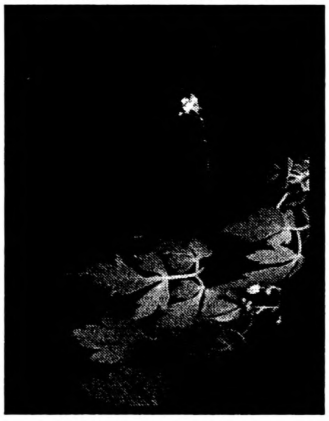

Fig. 2.1 *Cardiospermum halicacabum* (Wel-penela Plant)
(Source: Pickering 2007)

2.3.5 Food use

Leaves are eaten as a green vegetable. Extract of whole plant is added to the porridge.

2.3.6 Nutritional and Therapeutic value

Nutritional composition per 100 g edible portion

Table 2.1 Proximate composition of Wel-penela leaves

Moisture	83.3 g
Energy	61 kcal
Protein	4.7 g
Fats	0.6 g
Carbohydrates	9.1 g

(Source: Jayaweera 1982)

2.3.7 Chemistry of plant

The whole plant *Cardiospermum halicacabum* contains saponins, traces of alkoloids, flavonoides, proanthocyanidin, apigenin and phytosterols (eg. Stigmasterol).

In the leaves lager amounts of saponins and alkoloids were found, also (+)-pinitol, apigenin, luteolin and chrysoeriol (Kodikara 2005).

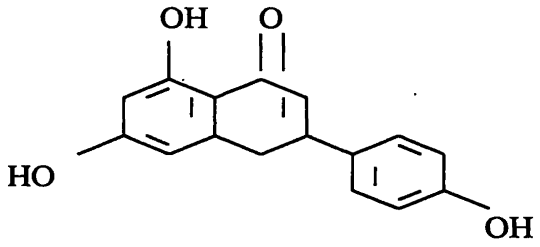

Fig. 2.2 Chemical structure of Apigenin

2.3.8 Medicinal uses

The whole plant is used both internally and externally in cases of rheumatism, nervous diseases, dropsy and orchitis. The juice of the plant is used as ear drops for earache.

In Africa, an infusion of the leaf is given as an enema for dysenteries and diarrhea and taken internally for general outbreak of sores in the body.

The root is a laxative, demulcent, diuretic and used in nervous diseases (Rajapaksha 1998).

2.4 Rice (*Oryza sativa*)

Scientific classification

Kingdom : Plantae

Division : Magnoliophyta

Class : Liliopsida

Order : Poales

Family : Poaceae

Genus : *Oryza*

Species : *O. sativa*

Common name : Rice

Rice is the staple food for two-thirds of the world's population. Rice is a wholesome and nutritious cereal grain and it has qualities, which make it ideally suited for special dietary needs.

It contains only 103 calories per half-cup serving of white rice and 108 calories per half-cup serving of brown rice. It is cholesterol-free, fat-free, sodium-free, a complex carbohydrate, gluten-free and non-allergenic and easy to digest. Following table shows the proximate composition of Brown rice.

Table 2.2 Proximate composition of Brown rice for 98g cooked

Moisture (%)	71.3
Food Energy (kcal)	108
Total Carbohydrates(g)	22.4
Dietary Fiber (g)	1.8
Protein (g)	2.5
Fat (g)	0.9
Ash (g)	0.45
Iron (mg)	0.4
Riboflavin (mg)	0.02
Vitamin E (mg)	0.7
Calcium (mg)	10
Phosphorous (mg)	81
Potassium (mg)	42

(Source: USDA National Nutrient Database for Standard Reference 2007)

2.5 Coconut (*Cocos nucifera*)

Scientific classification

Kingdom : Plantae

Division : Magnoliophyta

Class : Liliopsida

Order : Arecales

Family : Arecaceae

Genus : *Cocos*

Species : *C.nucifera*

Common name : Coconut

Coconut is a simple dry fruit known as a fibrous drupe (not a true nut). The mesocarp is composed of fibers called coir and there is an inner "stone" called the endocarp. This hard endocarp has three germination pores that are clearly visible on the outside surface once the husk is removed. Adhering inside wall of endocarp is the testa with a thick albuminous endosperm, the coconut meat, the white and fleshy edible part of the seed.

Dehydrated coconut milk powder is made by using spray drying technique and it has good keeping quality, gives greater convenience, and retains natural flavor and texture (Lombard, 2001).

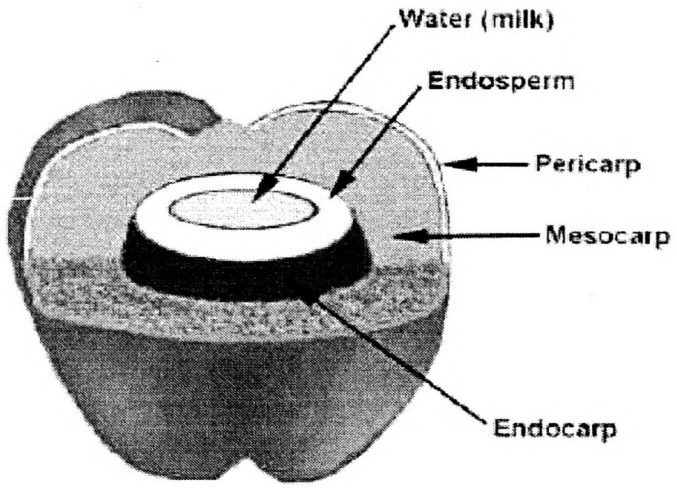

Fig.2.3 Cross section of fibrous drupe of coconut (*Cocos nucifera*) fruit
(Source: Lombard 2001)

Table 2.3 Approximate composition of endosperm (% fresh weight)

Composition	% fwt
Water	44-52
Oil	35-38
Carbohydrates	9-11
Protein	3-4
Crude Fiber	2-4
Ash	1

(Source: Ohler 1999)

Table 2.4 Fatty acid composition of coconut oil

Fatty Acid	Carbon Chain	% Composition
Caproic	C6	0.5
Caprylic	C8	8.0
Capric	C10	6.4
Lauric	C12	47.3
Myristic	C14	17.6
Palmitic	C16	8.4
Stearic, Oleic, Linoleic	C18	10.5

(Source: Ohler 1999)

2.6 Salt

It is a crystalline solid, white, pale pink or light green in color, obtained from sea water or from rock deposits. Treating food with salt was one of the earliest methods of food preservation. The reason for inhibition of bacteria by salt is not readily apparent. It is thought to be primarily a plasmolytic effect, dehydration, removal of oxygen, interference with enzymes, altering of pH or at high concentration, that sodium or chloride ions become toxic (Gould and Russell 1991).

2.7 Garlic

Garlic (*Allium sativum*) is bulb belonging to the family of onions, but it is far more pungent with a very piercing flavor. If it is used, chopped and fried it gives a more pronounce flavor. It is generally used in all meat, fish curries and Seeni Sambols. Garlic has a diuretic effect and is a preventive against flatulence. It is also administered to relieve rheumatic pain.

2.8 Preservatives

Preservatives were added for the purpose of extending the shelf life of the product by preventing the growth of microorganisms which could otherwise cause food decay or spoilage.

2.8.1 Citric acid

Citric acid is a practically odorless, colorless solid, forming either translucent crystals or white granules or powder. The hydrated acid losses water when it is heated at 70°C to 75°C and has an apparent melting point at 100°C, but the anhydrous acid actually melts at 153°C. It also inhibits oxidation by chelating other metal ions. It can synergistic with ascorbic acid (Kyzlink 1990).

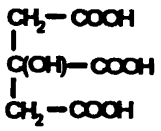

Fig. 2.4 Chemical structure of Citric acid

2.8.2 Ascorbic acid

Ascorbic acid is an organic acid with antioxidant properties. Its appearance is white to light yellow crystals or powder. It is water soluble. Exposure to oxygen, metals, light and heat destroy ascorbic acid, so it must be stored in dark and cold and not in a metal container. Reactive oxygen species oxidize ascorbate first to monodehydroascorbate and then dehydroascorbate. The reactive oxygen species are reduced to water while the oxidized forms of ascorbate are relatively stable and unreactive, and do not causes cellular damage (Gould and Russell 1991).

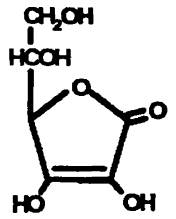

Fig. 2.5 Chemical structure of Ascorbic acid

2.8.3 Sodium Benzoate (SB)

It is widely used in preserving acid foods such as apple cider, margarine, pickle relishes and other acid foods. The benzoates generally are more effective against yeasts and molds than against bacteria in concentrations of 0.1% or less, the amounts allowed. While sodium salts of benzoic are commonly used, it is the benzoic acid molecule itself that appears to be germicidal. The undissociated molecule is thought to be active arrangement. The acidity of the substrate in which benzoates are added influence the effectiveness of the chemical preservative. In a food with a pH value of 7.0, benzoates are less effective than in an acid food, with a pH value near 3.0 (Gould and Russell 1991).

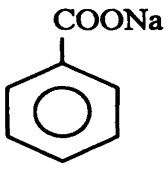

Fig. 2.6 Chemical structure of Sodium Benzoate

2.8.4 Sodium Metabisulfite (SMS)

The sulfites have an antimicrobial action against both fungi and bacteria. Gram negative bacteria are more susceptible than Gram positive types. Yeast is more resistant to SO_2 than either bacteria or molds. Sulfites are pH dependent. Sulfur dioxide (SO_2) combines with water to form sulfurous acid (H_2SO_4). This acid has two dissociation constants. These are near pH 2 and pH 7. At pH 5 most of the compound is in the form of bisulfite ion (HSO_3^-). At lower pH values, protonation of the bisulfite ion results in molecular SO_2.

Sulfites inactivate certain enzyme systems, such as cytochrome oxidase. The cytoplasmic membrane of bacterial cells is attacked by SO_2 which alters the permeability.

Sulfites combine with Acetaldehyde, the normal hydrogen acceptor required for glycolysis, and inhibit fermentation. There is evidence that bisulfite reacts with pyrimidine bases, so the antimicrobial activity may involve the RNA and DNA of microbial cells (Gould and Russell 1991).

2.9 Water

Potable water was used at all stages.

2.10 Glass Bottles Packaging

From the very earliest times, humans consumed food where it was found. Families and villages made or caught what they used. They were also self-sufficient, so there was little need for packaging of goods, either for storage or transportation. When containers were needed, nature provided gourds, shells, and leaves. Later, containers were fashioned from natural materials, such as hollowed logs, woven grasses and animal organs. As ores and chemical compounds were discovered, metals and pottery were developed, leading to other packaging forms.

Packaging is used for several purposes:

- Contain products, defining the amount the consumer will purchase.
- Protects products from contamination, from environmental damage and from theft.
- Facilitate transportation and storing of products.
- Carry information and colorful designs that make attractive displays.

Packaging in glass tended to be reserved for high- value products. As a type of "rigid packaging" glass has many uses today. High weight, fragility and cost have reduced the glass markets in favor of metal and plastic containers. Still, for products that have a high quality image and a desire for high flavor or aroma protection, glass is an effective packaging material. The packaging glass used today is the only type of glass accepted in United States recycling programs (Berger 2002).

Glass bottles for packing low-acid foods should be stored and handled in a clean and sanitary manner to minimize the chance of contamination or damage. The material of product containers should be appropriate for the product to be packed and sufficiently durable to withstand the processing and subsequent handling strains to which the containers are normally subjected.

2.11 Physiochemical Properties Assessment

2.11.1 pH

Because H+ concentrations vary over a wide range, it is convenient to introduce a special way to represent this concentration. When a quantity varies over a wide range of powers of 10, scientists often use a logarithmic scale to represent the quantity. For hydrogen ion concentration, the scale is called pH.

$$pH = - \log 10\ [H+] \text{ or, inversely, } [H+] = 10\text{-}pH$$

2.11.2 Total Soluble Solids (TSS)

Since the amount of sucrose dissolved in water is important industrially a whole series of measuring indices were developed to indicate the relative proportion of the two materials. The most important of these is a Brix scale, which relates the percentage by weight of sucrose in a water solution. The Brix scale is also used to measure solution other than pure sucrose and water (Knecht 1987).

2.12 Shelf life evaluation

Shelf life represents the useful storage life of food. At the end of shelf life, food is developing characteristics such as changes in taste, aroma, texture or appearance that are deemed unacceptable or undesirable. The underlying cause for the change may be microbiological, chemical or physical. Microbiological spoilage is exemplified by the above attributes.

2.12.1 Microbiology Spoilage

According to the acidity, foods may be divided into low-acid foods and acid foods. Low-acid food means any food, other than alcoholic beverages, where any component has a pH value greater than 4.6 after heat processing. These foods are considered perishable as pH above 4.6 may support growth of food spoilage or poisoning microorganisms such as *Clostridium botulinum*. A good manufacturing practice is essential to ensure the safety and quality of these food products (Curiale 1998).

2.13 Sensory evaluation

According to Cross et al. (1978) Sensory evaluation is a scientific discipline, through which the sensory analyst evokes, measures, analyzes and interprets human responses to stimuli as perceived through the senses.

2.13.1 Types of Panels

A. **Affective** - consumer panels

- Untrained
- Determine acceptable versus unacceptable

B. **Analytical** - trained panels

- Used in research or product development
- Determine intensity of characteristics

2.13.2 Selection of panel type

- Dependent on goals and nature of the product

A. Basic research

1. Analytical
2. Affective

B. New product development

1. Bench top
2. Analytical
3. Affective

C. Product optimization

1. Analytical

D. QA/QC

1. Analytical

- Each panel has its own specific goals and degree of training requirements

2.13.3 Affective panels

A. Measures consumer reactions to a particular product in terms of:

1. Acceptance/preference - 9 point hedonic scale
2. Difference/degree of difference between samples

B. Definition of population of interest

1. Who buys/consumes it
2. Limitations of population
3. Design questionnaire accordingly

C. Random sample

D. 50 to 100 (75 to 100)

E. Types of questionnaires:

1. Facial hedonic
2. Intensity scale

2.13.4 Analytical panels

A. Panelists function as human instruments in evaluating his/her objective impression of an attribute.

- Never ask a trained panelist to give a consumer response
- Select people with normal acuity

B. Panel consists of a group of subjects, who have been carefully screened, selected, trained and verified to objectively evaluate the test samples.

CHAPTER 03

MATERIALS AND METHODOLOGY

3.1 Materials

Materials for preparation of Wel-penela herbal porridge

Raw materials : Wel-penela leaves
Coconut milk
Brown rice
Garlic
Salt
Citric acid
Ascorbic acid
Sodium Benzoate
Sodium Metabisulfite
Water

Apparatus : Cutting board with a knife
Blender and Grinder
Strainer
Gas cooker
Spoons
Glass bottles with lids
Electronic thermometer (Quartz, AZ-668-SHR, -50°C~ +260°C)
Stainless Steel Vessels
pH meter (pH Scan WP2, +0.1 pH)
Hand Refractometer (Atago, ATC-1E, Brix 0-32)

Materials for Microbiological Analysis

Total Plate count (TPC)

Raw materials : Herbal porridge sample with Citric acid, SB and SMS
Distilled water
Plate count medium - for bacteria
Malt extract agar - for yeast and molds

Apparatus : Electronic Balance
Autoclave
Incubator

Bunsen Burners

Petri dishes, conical flasks, Beakers, Pipettes and other glass wares

Coliform Test

Raw materials : Herbal porridge sample with citric acid, SB and SMS

Distilled water

0.1% Peptone water

MacConkey broth

Brilliant Green Bile broth

Apparatus : Electronic Balance

Autoclave

Incubator

Bunsen Burners

Test tubes, conical flasks, Beakers, Pipettes and other glass wares

Materials for sensory evaluation

Raw materials : Bottled herbal porridge with Citric acid, SB and SMS

Bottled herbal porridge with Ascorbic acid, SB and SMS

Bottled herbal porridge with Acid control

Cream cracker biscuits

Glass of drinking water

Apparatus : Glasses

Spoons

Serviettes

Sensory ballet sheet

Pen

Materials for SO_2 determination

Raw materials : Bottled herbal porridge with Citric acid, SB and SMS

Tap water

Starch solution

Chemicals : 1 N NaOH solution

1:3 H_2SO_4 solution

I_2 solution

Apparatus : Conical flasks

Funnels

Burettes

Pipettes

Measuring cylinders (10 ml, 100 ml)

Burette holder

Beakers

Lids

3.2 Methodology

3.2.1 Preliminary survey

Preliminary market survey was conducted on important green leafy vegetables used to prepare herbal porridge. Hanwella MOH division was selected for survey and randomly selected 30 people were interviewed in Hanwella MOH division. The data were statistically analyzed by using computer aided MINITAB statistical Analysis package. Through the survey most consumer preference and most available green leafy vegetable variety in that area was selected to research work.

3.2.2 Preparation of natural herbal porridge using Wel-penela

Different combinations of different types of preservatives were used to make porridge to select the best combination which gives the better color, flavor and taste as follows.

Type 1: Wel-penela with Citric acid, SB and SMS

Type 2 : Wel-penela with Ascorbic acid, SB and SMS

Type 3 : Wel-penela with SB and SMS (Acid control)

Leaves

Fresh disease free leafy vegetable (Wel-penela) was harvested. Then it was sorted to remove unwanted parts (soil, dust, mud). After preliminary sorting, the immature leafy vegetable parts (leaves) were separated from whole plant manually. Then these leaves were properly washed by tap water and allowed to drain and chopped into
small pieces which could be fed in to a blender-jar.

Rice

Rice was broken into coarse particles by mild grinding.

Coconut milk

Thick coconut milk was obtained by first extracting of the blended scraped coconut.

Salt

Normal pure iodized table salt was used.

Garlic

Fresh disease free garlic was chopped.

Glass jars, lids, cutting board, knife, vessels and spoons were sterilized using boiling water. Herbal extract was obtained by cutting, blending and squeezing the mass with water. Grounded rice was boiled with chopped garlic about 20-30 min. until it got soften. Then the prepared coconut milk and herbal extract were added to the boiled ingredients and the mixture was re-boiled for another 5-10 min. and salt was added. Then preservatives were added after the mixture was taken out of the flame. The prepared porridge was in the liquid form, was poured in to glass jars immediately and was exhausted in the hot water bath until the center of the liquid was 82°C and was kept about 10 min. Then it was sealed immediately and cooked the jars at 85°C at 25 min. After labeling jars were stored at ambient temperature.

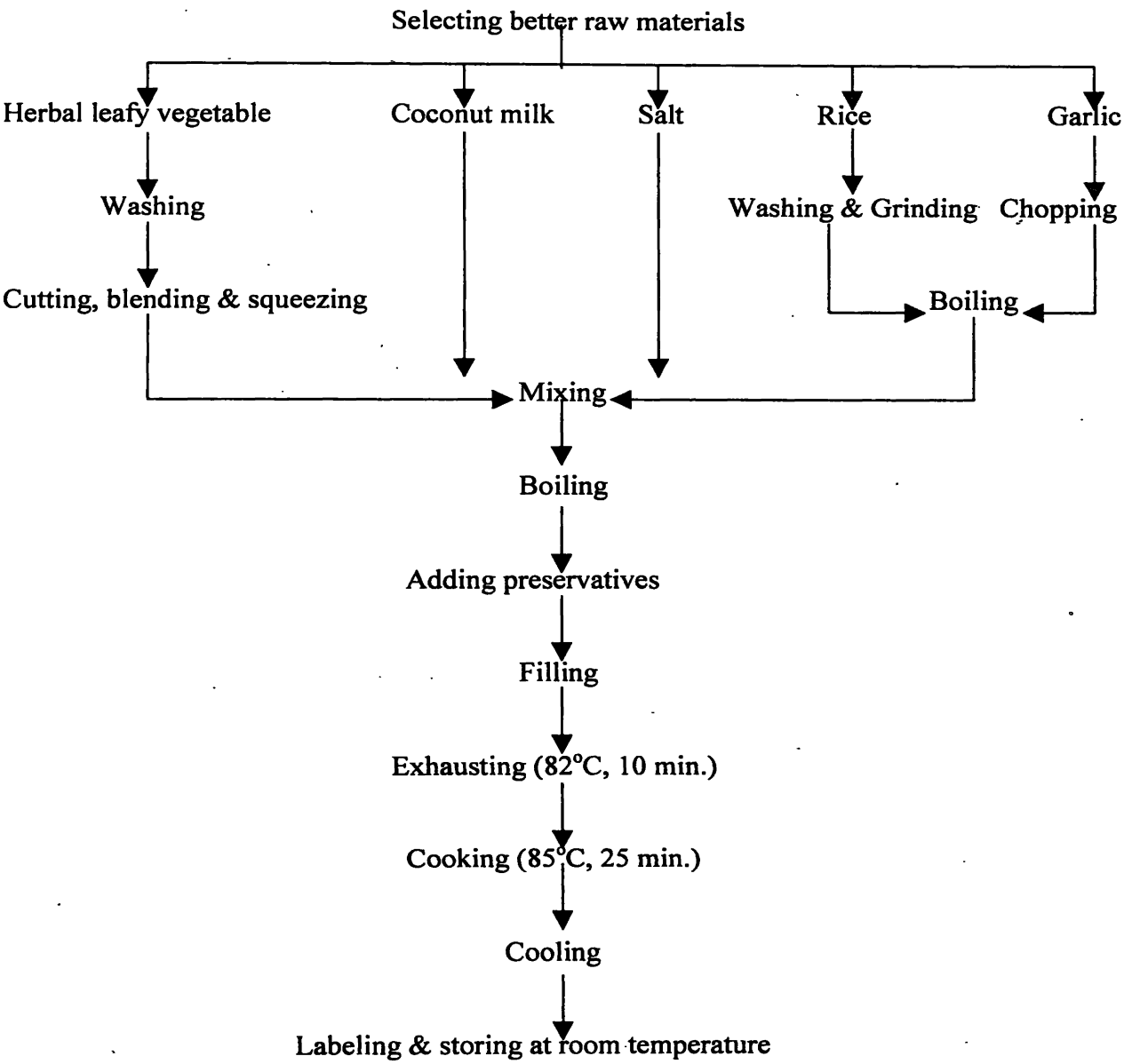

Fig. 3.1 Flow diagram of bottled herbal porridge manufacturing process

3.2.3 Sensory Analysis

After 14 days each sensory parameter (color, taste, flavor, thickness, overall appearance) were

evaluated by 30 semi trained sensory panelists (See App. II) for Type 1, Type 2 and Type 3 samples. Results were analyzed using computer aided MINITAB statistical Analysis package according to Kruskal-Wallis test at 95% level of significant level (See App. VII).

Finally, to see whether there is any difference between equal quantity of bottled Type 1 and immediately prepared herbal porridge without any preservatives, used 9- point Hedonic scale with 30 semi trained sensory panelists (See App.III).

Results were analyzed using computer aided MINITAB statistical Analysis package according to Paired T- Test at 95% level of significant level (See App. VII).

3.2.4 Studies on physicochemical changes during storage and shelf life evaluation of Bottled herbal porridge

Stored samples under ambient temperature were evaluated over two weeks for pH and TSS with four days interval.

3.2.4.1 Physicochemical Assessments

3.2.4.1.1 Determination of pH

1) Calibration of pH meter

The protective cap was removed and tip of the electrode was dipped into sterilized water heater and waited until stable value was displayed. Two buffer solutions were (pH 7.0 and pH 4.0) prepared by dissolving buffer capsules in distilled water. After that the pH meter was cleaned and dried and the tip of the electrode was immersed in to the pH 7.0 buffer solution. The pH meter was calibrated to pH 7.0 by using screw type equipment. After that pH meter was measured into pH 4.0 buffer solutions and calibrated to pH 4.0.

2) Measuring the pH

Sample was put into a beaker and pH meter was immersed into it. Then pH value was read directly.

3.2.4.1.2 Determination of TSS

Two three drops of herbal porridge was placed on the glass platform of the refractometer. Then the reading was taken and glass platform was cleaned by washing with distilled water and dried it using blotting paper.

3.2.5 Microbiological Analysis

3.2.5.1 Total Plate count (Aerobic Plate count)

Petri dishes, pipettes and test tubes were oven dried for 1 hr at 170°C. 1 g of herbal porridge sample was taken and put in to a sterile test tube containing 10 ml of sterile distilled water and was taken as a 10^{-1} dilution and further diluted up to 10^{-5} using sterile distilled water.

Transferring of solution was done using sterile pipettes. Then dilution series were prepared as follows.

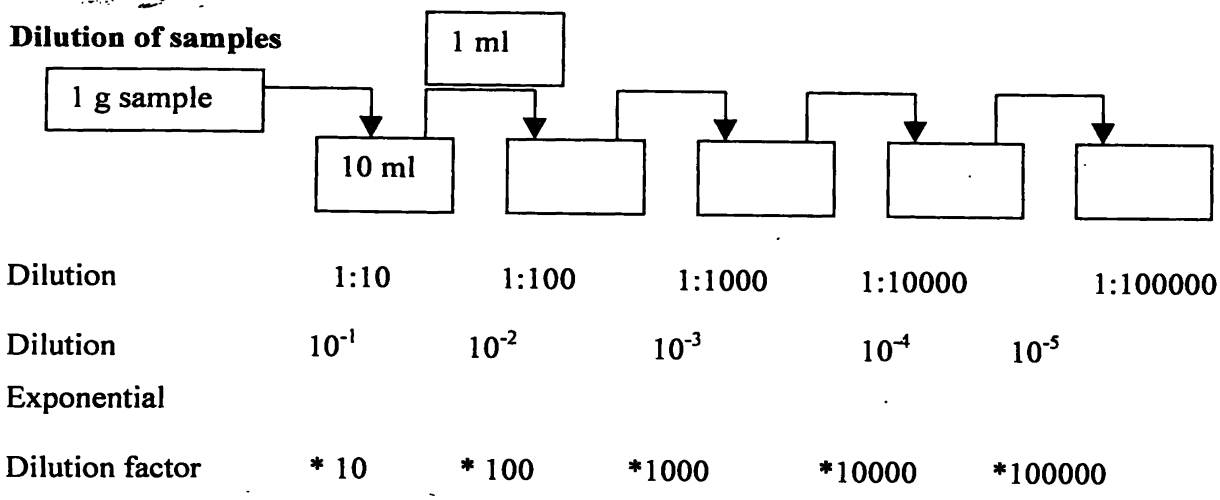

Fig. 3.2 Diagram of dilution of samples

Then two plates were prepared by using each dilution.

15 ml of the Plate Count medium and Malt extract agar at 45 ± 0.5^{0}C was poured into each Petri dish. Then the inoculum and the poured medium were mixed gently by rotating the plates clockwise and anti-clockwise and kept on a clean horizontal surface until it gets solidified. The dishes were inverted and incubated at 30 ± 10^{0}C or 72 ± 3 hrs for bacteria and yeast and molds (SLS 516: Part I: 1991 and SLS 516: Part II: 1991).

3.2.5.2 Coliform Test

1) Examination for presumptive Coliforms

Serial decimal dilutions of the sample were prepared using 0.1% peptone solution as the diluents. Then 1 ml of each of the dilutions were poured into each of three separate tubes of 10 ml quantities of single strength MacConkey broth by using a pipette. Then tubes were incubated at 36 ± 1^{0}C for 24 hrs and 48 hrs. Then tubes were examined at the end of 24 hrs for acid and gas production. Then negative tubes were re-incubated for an addition 24 hrs and tubes showing acid and gas production after 48 hrs were recorded. Tubes showing acid and gas production after 24 hrs and 48 hrs incubation is considered positive for presumptive Coliform.

2) Conformation of Coliforms

Sub cultured a loopful from each of the positive tubes from previous test into tubes containing 10 ml quantities of Brilliant Green Bile broth (BGB). Tubes were incubated at 36 ± 1^{0}C for 24 hrs to 48 hrs. BGB tubes were observed for gas production after 24 hrs and 48 hrs of incubation. Then all BGB tubes showing gas production was recorded as positive for

confirmed Coliforms(SLS 516: Part III: 1982).

3.2.6 SO_2 Analysis

25 ml of the sample from Type 1 was taken and 100 ml of water was added to it. Then 25 ml of 1 N NaOH was added to it and was kept 10 min. in dark. After that 10 ml of 1:3 H_2SO_4 and one drop of starch were added. Finally the solution was titrated with 0.025 I_2 until it appears blue color end point (SLS 214, 729: 1991).

CHAPTER 04

RESULTS AND DISCUSSION

4.1 Preliminary survey

According to the preliminary market survey conducted to identify the consumer preference on different leafy vegetables, Wel-penela (*Cardiospermum halicacabum*) was found to be the most popular one. How ever basing on two factors considered namely preference and availability in the area, Wel-penela (*Cardiospermum halicacabum*) was prioritized for further studies.

4.2 Sensory Analysis

4.2.1 Effect of preservatives on color to select best porridge sample

The results show the highest rank for the product, which contain citric acid, SB and SMS in the formula. According to data analysis there is a significant difference between the samples, since probability value p =0.000 of the test is less than the minimum probability value p=0.05. According to the data sample with citric acid, SB and SMS gained the highest estimated median for color. Therefore this sample comes under category of "Like very much" according to the 9- point hedonic scale.

Table 4.1 Effect of preservatives on color to select best porridge sample.
(457: Citric acid, SB, SMS; 523: Ascorbic acid, SB, SMS; 682: SB, SMS)

Sample code	N	Estimated median	Sum of rank
457	30	8.000	58.5
523	30	6.000	20.4
682	30	8.000	57.5

4.2.2 Effect of preservatives on taste to select best porridge sample

The results show the highest rank for the product, which contain citric acid, SB and SMS in the formula. According to data analysis there is a significant difference between the samples, since probability value p =0.000 of the test is less than the minimum probability value p=0.05. According to the data sample with citric acid, SB and SMS gained the highest estimated median for taste. Therefore this sample comes under category of "Like very much" according to the 9- point hedonic scale.

Table 4.2 Effect of preservatives on taste to select best porridge sample.
(457: Citric acid, SB, SMS; 523: Ascorbic acid, SB, SMS; 682: SB, SMS)

Sample code	N	Estimated median	Sum of rank
457	30	8.000	64.7
523	30	8.000	41.0
682	30	7.000	30.8

4.2.3 Effect of preservatives on flavor to select best porridge sample

The results show the highest rank for the product, which contain citric acid, SB and SMS in the formula. According to data analysis there is a significant difference between the samples, since probability value p =0.000 of the test is less than the minimum probability value p=0.05. According to the data sample with citric acid, SB and SMS gained the highest estimated median for flavor. Therefore this sample comes under category of "Like moderately" according to the 9- point hedonic scale.

Table 4.3 Effect of preservatives on flavor to select best porridge sample
(457: Citric acid, SB, SMS; 523: Ascorbic acid, SB, SMS; 682: SB, SMS)

Sample code	N	Estimated median	Sum of rank
457	30	7.00	50.0
523	30	7.00	47.1
682	30	6.00	39.4

4.2.4 Effect of preservatives on thickness to select best porridge sample

The results show the highest rank for the product, which contain citric acid, SB and SMS in the formula. According to data analysis there is a significant difference between the samples, since probability value p =0.000 of the test is less than the minimum probability value p=0.05. According to the data sample with citric acid, SB and SMS gained the highest estimated median for thickness. Therefore this sample comes under category of "Like very much" according to the 9- point hedonic scale.

Table 4.4 Effect of preservatives on thickness to select best porridge sample (457: Citric acid, SB, SMS; 523: Ascorbic acid, SB, SMS; 682: SB, SMS)

Sample code	N	Estimated median	Sum of rank
457	30	8.000	58.0
523	30	7.000	41.8
682	30	4.000	36.7

4.2.5 Effect of preservatives on overall appearance to select best porridge sample

The results show the highest rank for the product, which contain citric acid, SB and SMS in the formula. According to data analysis there is a significant difference between the samples, since probability value p =0.000 of the test is less than the minimum probability value of p=0.05. According to the data sample with citric acid, SB and SMS gained the highest estimated median for overall appearance. Therefore this sample comes under category of "Like very much" according to the 9- point hedonic scale.

Table 4.5 Effect of preservatives on overall appearance to select best porridge sample (457: Citric acid, SB, SMS; 523: Ascorbic acid, SB, SMS; 682: SB, SMS)

Sample code	N	Estimated median	Sum of rank
457	30	8.000	60.6
523	30	6.000	30.9
682	30	7.000	45.1

Table 4.6 The comparison between natural herbal porridge and preserved herbal porridge

No. of panelists	Sample B 345	Sample A 162	Difference
1	8	7	1
2	7	7	0
3	9	7	2
4	9	8	2
5	6	7	-1
6	7	8	-1
7	8	9	-1
8	7	8	-1
9	8	9	-1
10	7	8	-1
11	7	9	-2
12	7	8	-1
13	7	8	-1
14	7	9	-2
15	6	8	-2
16	8	6	2
17	8	7	1
18	9	8	1
19	8	7	1
20	7	8	-1
21	9	8	1
22	8	7	1
23	8	7	1
24	9	8	1
25	8	7	1
26	8	8	0
27	8	7	1
28	8	7	1
29	8	9	-1
30	9	8	1
Total	233	232	2
Avg.	7.76	7.73	0.66

345- Immediately prepared herbal porridge sample without any preservatives

162- Bottled herbal porridge sample with citric acid, SB and SMS after 14 days stored in ambient temperature

At 95% confidence level there was no significant difference observed between immediately prepared herbal porridge sample without any preservatives and bottled herbal porridge sample with citric acid, SB and SMS. The p-value ($p = 0.882$) further suggests that the data were consistent with H_0: $\mu d = 0$, that is, the two samples do perform equally. Specifically, sample 345 (mean = 7.76667) performed better than sample 162 (mean = 7.73333) in terms of sensory attributes (See App.VII).

4.3 Shelf life evaluation

4.3.1 Physiochemical storage studies

Final selected sample stored for two weeks at room temperature and chemical storage studies (pH, Brix value) were observed in this storage period at room temperature ($27^0C \pm 3^0C$). There were no changes in the pH and Brix value with in two weeks. The results revealed that product was acceptable for two weeks.

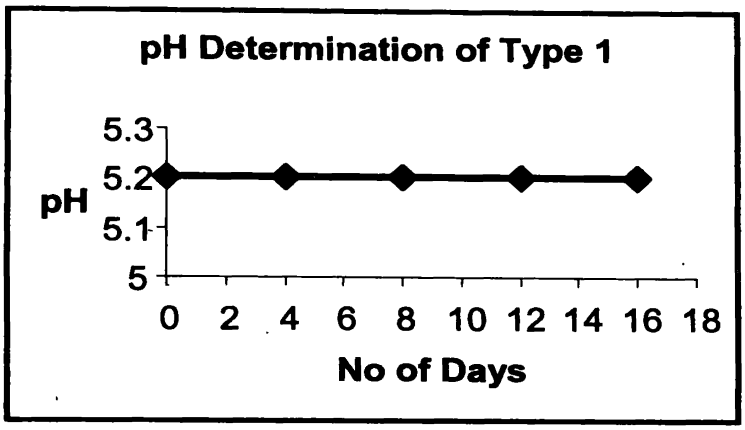

Fig. 4.1 pH vs. Days graph

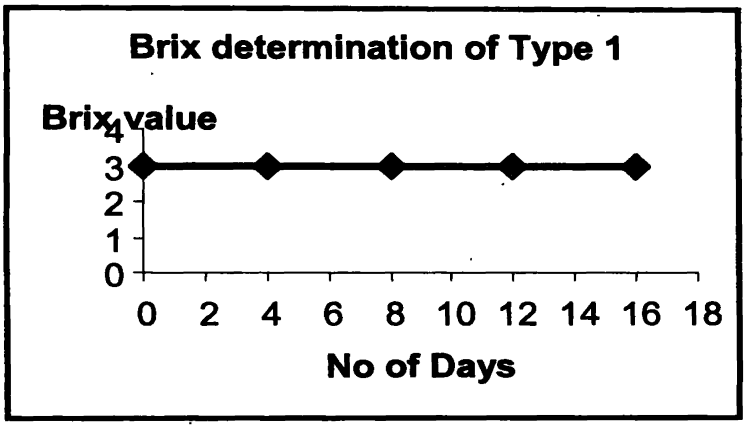

Fig. 4.2 Brix value vs. Days graph

4.3.2 Microbial Evaluation

4.3.2.1 Total Plate count (Aerobic Plate count)

According to the results 8.2×10^2 per ml of bacteria and 5×10^1 per ml of yeast and molds were contained in the bottled herbal porridge after two weeks of ambient storage (See App.IV).

4.3.2.2 Coliform Test

Coliform was not detected in the bottled herbal porridge after two weeks of ambient storage. Presence of Coliform indicates generally poor sanitation condition (See App.V).

4.4 SO_2 Determination

The calculated amount of residual SO_2 in the herbal porridge sample with citric acid, SB and SMS was 64 ppm (See App.VI).

4.5 Formulation of bottled herbal porridge

Type 1 bottled herbal porridge was selected as best formulation after conducting sensory analysis for color, taste, flavor, thickness and overall appearance parameters.

Table 4.7 Ingredients of formulated bottled herbal porridge

Ingredients	Quantity (g) per bottle	Percentage per bottle
Herbal extract	68	26%
Coconut milk	87.5	34%
Rice	12.5	4.8%
Garlic	2.5	0.97%
Salt	2	0.77%
Citric acid	0.075	0.03%
Sodium benzoate	0.06	0.023%
Sodium Metabisulfite	0.05	0.02%
Water added	84	33%

Fig. 4.3 Final product of bottled herbal porridge

Discussion

Heating on starchy foods causes the starch to pre gelatinization which makes it to easier to digest. Pre gelatinized starch also takes less time to prepare. Heating can also destroy anti nutritional factors (these blocks such as trypsin inhibitors and some tannin).

Green leaves which were fortified are rich in Beta carotene and contain some iron. Chlorophyll is affected by both heat and acid and changes to olive green as the chlorophyll decomposes.

The apple green color of leaves and other parts of plants is largely due to the oil soluble chlorophylls, which in nature are bound to protein molecules in highly organized complexes. When the plant cells are killed by ageing, processing, or cooking, the protein of these complexes is denatured and the chlorophyll may be released. Such chlorophyll is highly unstable and rapidly changes in color to olive green and brown. This color change is believed to be due to the conversion of chlorophyll to the compound pheophytin. Conversion to pheophytin is favored by acid pH (Dauthy 1995).

Heating at higher degree causes flocculation of coconut milk. Slight amount of coalescence observed after heating greater than 80^0C. Heated coconut milk form layer called cream layer, because flocculated droplets packed together less efficiently.

Thermal exhausting heats and expands the food and releases gasses mainly carbon dioxide and oxygen from the cells. Air is also excluded by the expansion of the food. The objective of the thermal process is to destroy vegetative microbial cells of public health significance, and those of non-health significance capable of reproducing in the food during normal conditions of storage and distribution.

Safe heat treatments of foods intend for ambient storage in sealed containers are designed on the basis of the preservative effect of the food pH after heat processing. Sterilization process for low acid foods is made on the basis of the minimum growth pH of *Clostridium botulinum* under optimum conditions.

Citric acid is contained naturally in lots of fruits and vegetables, so incorporation of citric acid to food is harmless (Sarananda 2002). Sodium benzoate as a weak lipophilic organic acid is incompletely dissociated and their antimicrobial activity relies on the H^+ concentration and additional inhibitory effects from the undissociated acid or its anion. Sodium metabisulfite as an inorganic anion caused strong effect in retarding oxidation, preventing discoloration and loss of flavor of product.

Sensory analysis was used to show consumer acceptability and the high degree of evaluation of the product. According to the results of sensory analysis the median attributes of color, taste, flavor, texture and overall results were significantly high in Type 1. Therefore, the herbal porridge with citric acid, SB and SMS was selected as the best for further development.

The apple green color in Type 1 was given by dissociation of Magnesium from chlorophyll phytic tail, because of its low pH than Type 2 and Type 3. Type 2 and Type 3 were observed dark green color due to high pH than Type 1.

According to the microbiology analysis, Total Plate Count and Coliform Count were done and results showed that the bacterial and fungal counts were low in the samples after two weeks of ambient storage. No Coliform count was observed in the product even after two weeks. Presence of bacteria due to contamination during processing from air, water, personnel involvement and equipments and utensils. Aseptic sterile environment will be better solution to this problem.

The Kolakenda herbal soups presently available in the market need some culinary effort before consumption. So there was no similar product in the market for comparison. Wel-penela pills and capsules available in the market are very popular among consumers. Since herbal porridge cups are available in the local market at Rs.15.00, bottled herbal porridge as a value added product can be sold at Rs.25.00 per bottle in the local market as a profitable product.

CHAPTER 05

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- Bottled herbal porridge is an instant, ready-to-consume and health product which helps rejuvenation of adults and good for people with busy life style.
- Herbal porridge with Citric acid, Sodium benzoate and Sodium metabisulfite is the best combination of preservatives used for preparation.
- The quality parameters (pH and TSS) of Type 1 bottled herbal porridge retained constant during study period.
- There is no significant difference at 5% level between immediately prepared herbal porridge without any preservatives and Type 1 bottled herbal porridge.
- Amount of residual SO_2 available in Type 1 bottled herbal porridge stored under room temperature for two weeks is 64 ppm and it is below the level of recommended standards of ready to serve product.
- According to the results of Total Plate Count for bacteria in Type 1 bottled herbal porridge was 8.2×10^2 per ml after two weeks of ambient storage. Viable bacteria can grow in low acid media.
- Total Plate Count for yeast and molds in Type 1 bottled herbal porridge was 5.0×10^1 per ml after two weeks of ambient storage. Viable yeast and molds can grow in low acid media. Aseptic sterile environment will reduce contamination.
- According to the results of Coliform test of the Type 1 bottled herbal porridge was negative after two weeks of ambient storage and was confirmed the absence of Coliforms.
- Bottled herbal porridge of Wel-penela can be stored for two weeks at ambient conditions without any significant quality deterioration. Thus the success of bottled herbal porridge of Wel-penela can be stated.

5.2 Recommendation

- Bottled herbal porridge of Wel-penela can be reinforced with Soya, Mung bean, Vitamin premixes and other additives such as spices and condiments like ginger, cloves etc, to serve specific nutritional purposes.
- Bottled herbal porridge of Wel-penela can be modified to suit the consumer palatability by adding sweeteners like honey, jaggery.
- Nutrients content of bottled herbal porridge of Wel-penela should be studied further.

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APPENDIX I

QUESTIONNAIRE

1. What are the leafy vegetables, you used to prepare herbal porridge?
2. What is the most available leafy vegetable in this area?
3. Where do you find that leafy vegetables?
4. What is the most consumer preference?
5. What is /are the medicinal value of these leafy vegetables?
6. What is /are the nutritional value as a fortification of herbal porridge?

Leafy vegetables	Availability	Place	Consumer preference	Medicinal values	Nutritional values

APPENDIX II

SENSORY EVALUATION BALLET SHEET

Name :

Date :

Product :

A) Taste these three samples and mention how you like or dislike each one.

9- Like extremely

8- Like very much

7- Like moderately

6- Like slightly

5- Neither like nor dislike

4- Dislike slightly

3- Dislike moderately

2- Dislike very much

1- Dislike extremely

Characters	457	523	682
Color			
Taste			
Flavor			
Thickness			
Overall acceptability			

B) Put a tick (×) in relevant box.

a) Taste

	457						523						682					
Characters	Less					More	Less					More	Less					More
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Bitterness																		
Sweetness																		
Sourness																		
Saltiness																		

b) Smell

Characters	457	523	682
Leafy smell			
Rice smell			
Coconut milk smell			
Garlic smell			
Other smell			

If any other smells, specify it .....

Comments :

Thank you.

APPENDIX III

SENSORY EVALUATION BALLET SHEET

Name :

Date :

Product :

Taste these two samples and mention how you like or dislike each one.

9- Like extremely
8- Like very much
7- Like moderately
6- Like slightly
5- Neither like nor dislike
4- Dislike slightly
3- Dislike moderately
2- Dislike very much
1- Dislike extremely

Sample No.	Sample No.
345	162

Comments:

Thank you.

APPENDIX IV

TOTAL PLATE COUNT CALCULATION

$$N = \frac{\epsilon C}{(n_1 + 0.1\, n_2)\, d}$$

N = No. of microorganisms per ml/per g of sample

ϵC = Sum of all colonies counted on all the Petri dishes

n_1 = No. of Petri dish in first dilution counted

n_2 = No. of Petri dish in second dilution counted

d = Dilution factor corresponding to the first dilution

APPENDIX V

MPN TABLE

No. of positive tubes for the three dilution factors retained			MPN	Confidence limits			
0	0	0	0.3				
0	1	0	0.3	0.1	2.3	0.1	1.7
1	0	0	0.4	0.1	2.8	0.1	2.1
1	0	1	0.7	0.1	3.5	0.2	2.7
1	1	0	0.7	0.1	3.6	0.2	2.8
1	2	0	1.1	0.2	4.4	0.4	3.5
2	0	0	0.9	0.1	5.0	0.2	3.8
2	0	1	1.4	0.3	6.2	0.5	4.8
2	1	0	1.5	0.3	6.5	0.5	5.0
2	1	1	2.0	0.5	7.7	0.8	6.1
2	2	0	2.1	0.5	0.8	0.8	6.3
3	0	0	2.3	0.4	17.7	0.7	12.9
3	0	1	4	1	25	1	18
3	1	0	4	1	29	2	21
3	1	1	7	2	37	2	28
3	2	0	9	2	52	3	39
3	2	1	15	3	66	5	51
3	2	2	21	5	82	8	64
3	3	0	20	10	190	10	140
3	3	1	50	10	320	20	240
3	3	2	110	20	640	30	480
3	3	3	110				

APPENDIX VI

CALCULATION OF SO_2

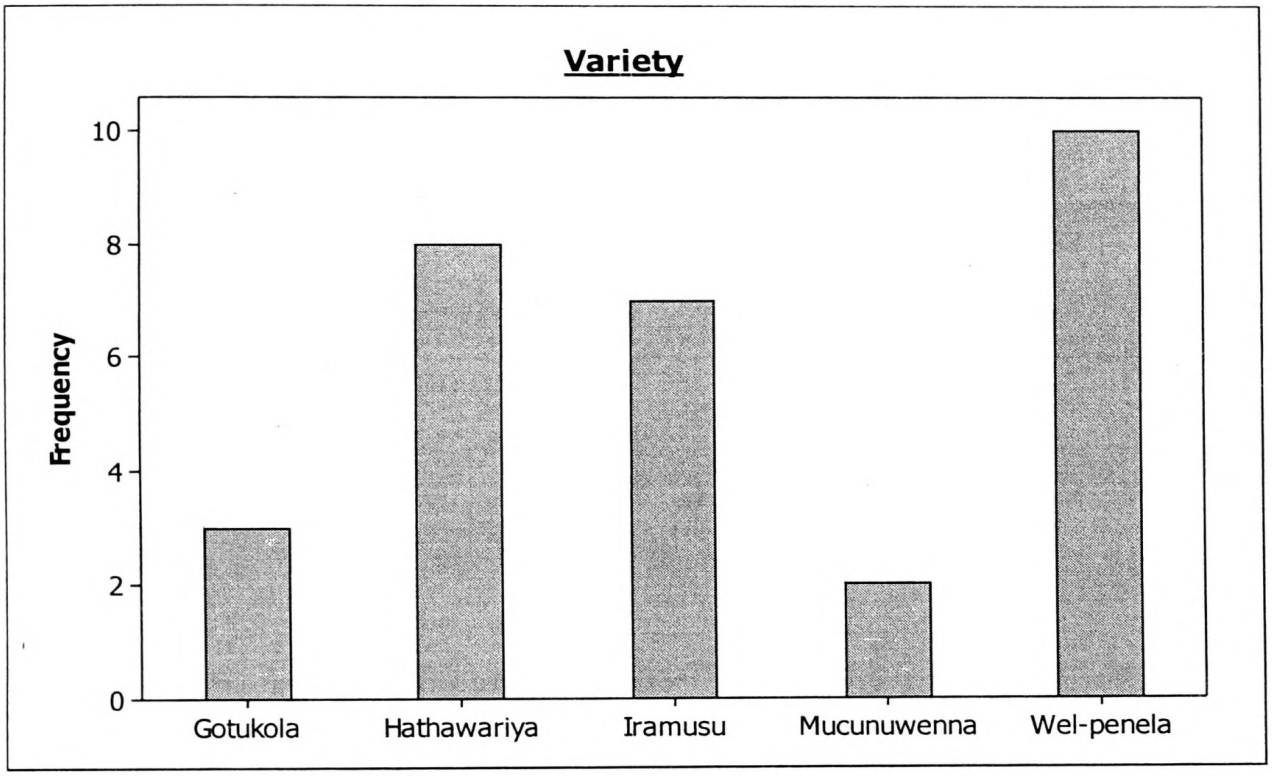
SO_2 ppm = 64 x V

V = Volume of I_2 required for titration

APPENDIX VII

Statistically described data of the preliminary market survey

Variety	Preference
Gotukola	03
Mucunuwenna	02
Wel-penela	10
Hathawariya	08
Iramusu	07



Highest frequency (10) goes to Wel-penela and it is considered as the most consumers preferred one.

Statistical Analysis data of sensory evaluation

Kruskal-Wallis Test: For color

C5	N	Median	Ave Rank	Z
Acid Control	30	8.000	57.5	3.09
Ascorbic acid	30	6.000	20.4	-6.44
Citric acid	30	8.000	58.5	3.35
Overall	90		45.5	

H = 41.45 DF = 2 P = 0.000
H = 47.54 DF = 2 P = 0.000 (adjusted for ties)

Kruskal-Wallis Test: For taste

C5	N	Median	Ave Rank	Z
Acid control	30	7.000	30.8	-3.78
Ascorbic acid	30	8.000	41.0	-1.15
Citric acid	30	8.000	64.7	4.93
Overall	90		45.5	

H = 26.62 DF = 2 P = 0.000
H = 30.58 DF = 2 P = 0.000 (adjusted for ties)

Kruskal-Wallis Test: For flavor

C5	N	Median	Ave Rank	Z
Acid control	30	6.000	39.4	-1.56
Ascorbic acid	30	7.000	47.1	0.41
Citric acid	30	7.000	50.0	1.15
Overall	90		45.5	

H = 2.61 DF = 2 P = 0.272
H = 2.86 DF = 2 P = 0.239 (adjusted for ties)

Kruskal-Wallis Test: For thickness

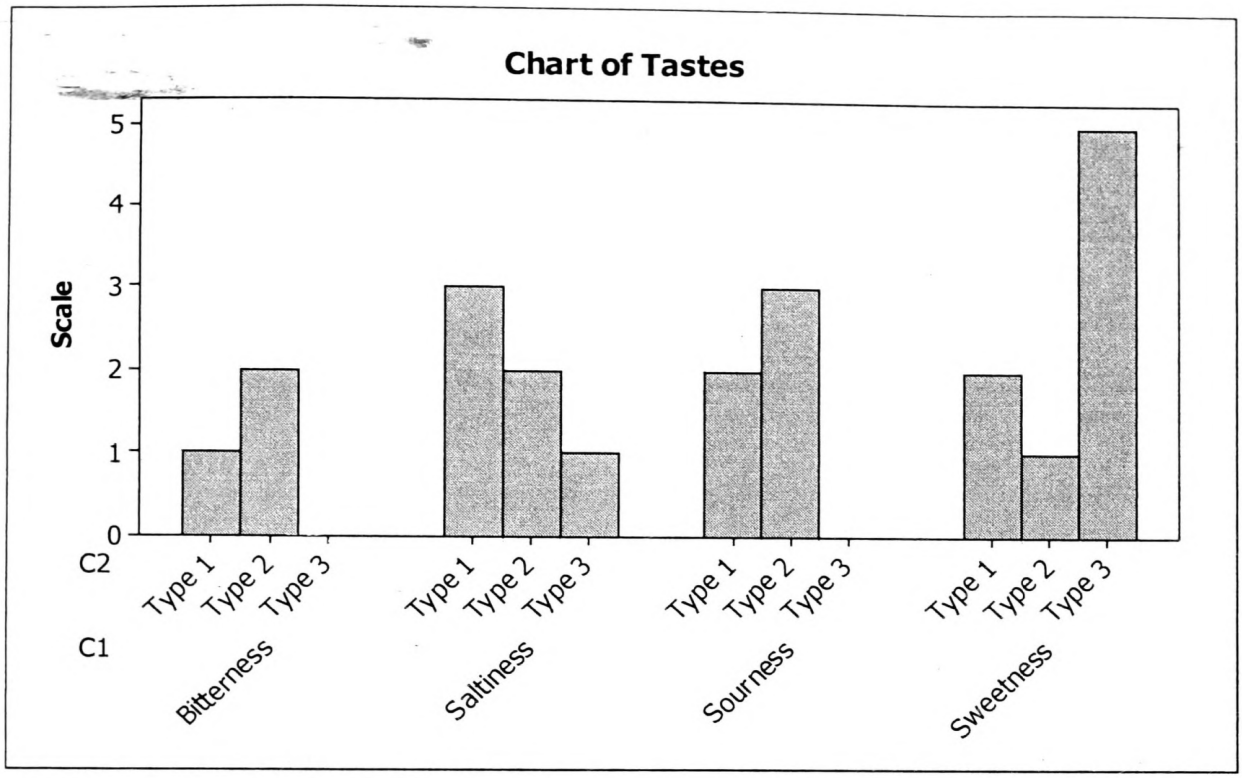
C5	N	Median	Ave Rank	Z
Acid control	30	4.000	36.7	-2.25
Ascorbic acid	30	7.000	41.8	-0.96
Citric acid	30	8.000	58.0	3.21
Overall	90		45.5	

H = 10.86 DF = 2 P = 0.004
H = 11.58 DF = 2 P = 0.003 (adjusted for ties)

Kruskal-Wallis Test: For overall appearance

C5	N	Median	Ave Rank	Z
Acid control	30	7.000	45.1	-0.12
Ascorbic acid	30	6.000	30.9	-3.76
Citric acid	30	8.000	60.6	3.88
Overall	90		45.5	

H = 19.47 DF = 2 P = 0.000
H = 21.50 DF = 2 P = 0.000 (adjusted for ties)



Type 1 has slight bitterness (1), moderate saltiness (3), slight sourness (2) and slight sweetness (2).

Type 2 has highest sourness than others.

Type 3 has highest sweetness than others.

Paired T-Test and CI: 345, 162

Paired T for 345 - 162

	N	Mean	StDev	SE Mean
345	30	7.76667	0.85836	0.15671
162	30	7.73333	0.78492	0.14331
Difference	30	0.033333	1.217214	0.222232

95% CI for mean difference: (-0.421182, 0.487848)

T-Test of mean difference = 0 (vs not = 0): T-Value = 0.15 P-Value = 0.8

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