PROCESSING AND PRESERVATION OF POWDER AND PASTE FROM DIFFERENT SPICES

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December 2018

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December, 2018

DEDICATED TO

MY BELOVED

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Table of Contents

Authorization i

Acknowledgements iii

List of Abbreviations x

List of figures xii

List of Tables xiii

Abstract xv

Chapter 1: Introduction 1

1.1 Aim of the study 7

1.2 Specific objectives of the study 7

Chapter 2: Review of Literature 8

2.1 Food Processing and Preservation 8

2.2 Food Processing and Preservation Method 8

2.3 Classification of Spices 9

1. Classification based on Degree of Taste: 10

2. Classification based on Plant Organs: 10

2.4 Nutritional value and properties of ginger 11

2.5 Nutritional value and properties of garlic 14

2.6 Nutritional value and properties of green chili 17

2.7 Effect of processing and preservation of ginger, garlic and green chili 19

Chapter 3: Materials and Methods 36

3.1 Site and period of study 36

3.2 Collection of sample 36

3.3 Sample identification 36

3.4 Processing and preservation techniques 37

3.4.1 Preparation of powder and paste 37

3.4.1.1 Pre-treatment of samples 37

3.4.1.2 Sun drying 37

3.4.1.3 Shade drying 37

3.4.1.4 Mechanical drying 37

3.4.2 Preparation of paste 37

3.5 Physicochemical properties 38

3.5.1 Determination of Total Soluble Solids 39

3.5.2 Determination of titrable acidity 39

3.5.3Determination of pH 39
3.6 Proximate composition analysis..39
3.6.1 Moisture determination..40
3.6.2 Protein determination..40
3.6.3 Fat Determination 41
3.6.4 Ash Determination..42
3.6.6 Determination of total carbohydrate 44
3.7 Determination of Vitamins 44
3.7.1 Analysis of vitamin C 44
3.7.2 Analysis of β-carotene: 45
3.8 Analysis of minerals 46
3.8.1 Determination of sodium (Na) 47
3.8.3 Determination of calcium (Ca)..49
3.8.5 Determination of iron (Fe) 51
3.9 Microbial analysis..53
3.9.1 Enumeration of Total Plate Count (TPC) of Spices 53
3.9.2 Enumeration of Total Coliforms of Spices..53
3.10 Sensory Evaluation of Powder and Paste 54
3.11 Statistical analysis..54
Chapter 4: Results 55
4.1 Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of ginger powder and paste 55
4.1.1 Ginger Powder..55
4.1.1.1 Changes in physicochemical parameter of ginger powder 55
4.1.1.2 Proximate composition of ginger powder 56
4.1.1.3 Vitamin and mineral content of ginger powder..57
4.1.1.4 Microbial analysis of ginger powder..58
4.1.1.5 Sensory evulation of ginger powder..59
4.1.2 Ginger Paste..59
4.1.2.1 The effects of temperature and storage time on the physicochemical parameter of ginger paste packed in plastic bottle. 59
4.1.2.2 The effects of temperature and storage time on the proximate composition of ginger paste packed in plastic bottle. 60
4.1.2.3. Changes of Vitamin C content of ginger paste..62
4.1.2.4 Changes of mineral content of ginger paste 63

4.1.2.5 Microbial analysis of ginger paste 64
4.1.2.6 Sensory characteristics of ginger paste 65
4.2. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of garlic powder and paste 66
4.2.1. Garlic Powder 66
4.2.1.1 Changes in physicochemical parameter of garlic powder 66
4.2.1.2 Change of Proximate composition of garlic powder 67
4.2.1.3 Vitamin and mineral content of garlic powder 68
4.2.1.4. Microbial analysis of garlic powder 69
4.2.1. 5 Sensory characteristics of garlic powder 70
4.2.2. Garlic Paste 71
4.2.2.1 The effects of temperature and storage time on the physicochemical parameter of garlic paste packed in plastic bottle. 71
4.2.2.2 The effects of temperature and storage time on the proximate composition of garlic paste packed in plastic bottle. 72
4.2.2.3 Changes of Vitamin C content of garlic paste 73
4.2.2.4 Changes of mineral content of garlic paste 74
4.2.2.5. Microbial analysis of garlic paste. 75
4.2.2.6 Sensory characteristics of garlic paste 76
4.3. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of green chili powder and paste 77
4.3.1 Green Chili Powder 77
4.3.1.1 Changes in physicochemical parameter of green chili powder 77
4.3.1.2 Change of Proximate composition of green chili powder 78
4.3.1.3 Changes of Vitamin and mineral content of green chili powder 79
4.3.1.4 Microbial analysis of green chili powder 80
4.3.1.5 Sensory characteristics of green chili podwer 81
4.3.2 Green Chili Paste 81
4.3.2.1 The effects of temperature and storage time on the physicochemical parameter of green chili paste packed in plastic bottle. 81
4.3.2.2 The effects of temperature and storage time on the proximate composition of green chili paste packed in plastic bottle. 83
4.3.2.3. Changes of β-carotene content of green chili paste 84
4.3.2.4 Changes of mineral content of green chili paste 85
4.3.2.5. Microbial analysis of green chili paste. 86
4.3.2.6. Sensory characteristics of green chili paste 87

Chapter 5: Discussion 88
5.1. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of ginger powder and paste 88
5.2. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of garlic powder and paste 92
5.3. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of green chili powder and paste 95
Chapter 6: Conclusion 100
Chapter 7: Recommendation and Future perspectives 101
References 102
Appendix-A: Ginger, Garlic and Green Chili collection and processed 120
Appendix-B: Analysis work carried out during research 121
Appendix C: Different drying process (Sun dried, Cabinet dried, Shade dried) 123
.... 125
.... 125
Appendix D: Powder and paste products 126
.... 126
Appendix F: Hedonic Rating Test 128
Biography 129

List of Abbreviations

Words	**Elaboration**
µg	Microgram
µl	Microlitre
A	Absorbance
AOAC	Association of Official Analytical Chemists
KMS	Potassium metabisulphate
SB	Sodium benzoate
MP	Mixed preservative
FAO	Food and Agricultural Organization
G	Gram
BBS	Bangladesh Bureau of Statistics
Mg	Milligram
mmol/L	Millimole/litre
PPM	Parts Per Millions
USDA	United States Department of Agriculture
Na	Sodium
K	Potassium
Ca	Calcium
Mg	Magnesium
Fe	Iron
WHO	World health organization

%	Percent
Abs.S	Absorbance of the Standard
Abs.T	Absorbance of the Test Sample

List of figures

SL. No	Description of figure	Page no.
Fig 2.1.	Major food preservation methods	9
Fig. 4.1.	Microbial quality of ginger powder	58
Fig. 4.2.	Vitamin C content of ginger paste	62
Fig. 4.3.	Microbial quality of ginger paste	64
Fig. 4.4.	Microbial quality of garlic powder	69
Fig. 4.5.	Vitamin C content of garlic paste	73
Fig. 4.6.	Microbial quality of garlic paste.	75
Fig. 4.7.	Microbial quality of green chili powder	80
Fig. 4.8.	β-carotene content of green chili paste	84
Fig. 4.9.	Microbial quality of green chili paste.	86

List of Tables

SL.No.	Description of Tables	Pages
2.1.	Classification of Spices by Taste	10
2.2.	Plant Organs as Spices	10
2.3.	Nutritive value of Ginger (*Zingiber officinale Roscoe*) per 100 gm	14
2.4.	Nutritive value of Garlic (*Allium sativum Linn)* per 100 gm	17
2.5.	Nutritive value of Chilies (*Capsicum Annuum Longum*) per 100 gm	19
3.1.	Samples and sample codes	36
4.1.	Changes in physicochemical parameter of ginger powder	55
4.2.	Change of Proximate composition of ginger powder	56
4.3.	Changes of Vitamin and mineral content of ginger powder	57
4.4.	Mean score for color, flavor, Taste, appearance and overall acceptability of Ginger powder stored in plastic bottle	59
4.5.	The effect of room temperature (30ºC), storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the physicochemical parameter of ginger paste (packed in plastic bottle) from fresh ginger	60
4.6.	The effect of room temperature (30ºC) storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the proximate composition of ginger paste (packed in plastic bottle) from fresh ginger	61
4.7.	The effect of room temperature (30ºC), storage time on different concentrations preservative KMS on the mineral contents of ginger paste (packed in plastic bottle) from fresh ginger paste	63
4.8.	Mean score for color, flavor, Taste, appearance and overall acceptability of ginger paste stored in plastic bottle	65
4.9.	Changes in physicochemical parameter of garlic powder	66
4.10.	Change of Proximate composition of garlic powder	67
4.11.	Changes of Vitamin and mineral content of garlic powder	68
4.12.	Mean score for color, flavor, Taste, appearance and overall acceptability of garlic powder stored in plastic bottle	70

4.13.	The effect of room temperature (30ºC), storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the physicochemical parameter of garlic paste (packed in plastic bottle) from fresh garlic	71
4.14.	The effect of room temperature (30ºC) storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the proximate composition of garlic paste (packed in plastic bottle) from fresh garlic	72
4.15.	The effect of room temperature (30ºC), storage time on different concentrations preservative KMS on the mineral contents of garlic paste (packed in plastic bottle) from fresh garlic paste	74
4.16.	Mean score for color, flavor, Taste, appearance and overall acceptability of garlic paste stored in plastic bottle	76
4.17.	Changes in physicochemical parameter of green chili powder	77
4.18.	Change of Proximate composition of green chili powder	78
4.19.	Changes of Vitamin and mineral content of ginger powder	79
4.20.	Mean score for color, flavor, Taste, appearance and overall acceptability of green chili powder stored in plastic bottle	81
4.21.	The effect of room temperature (30ºC), storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the physicochemical parameter of green chili paste (packed in plastic bottle) from fresh green chili	82
4.22.	The effect of room temperature (30ºC) storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the proximate composition of green chili paste (packed in plastic bottle) from fresh green chili	83
4.23.	The effect of room temperature (30ºC), storage time on different concentrations preservative KMS on the mineral contents of green chili paste (packed in plastic bottle) from fresh green chili paste	85
4.24.	Mean score for color, flavor, Taste, appearance and overall acceptability of green chilli paste stored in plastic bottle	87

Abstract

Spices are important group of agricultural commodities, because of their taste and aroma. They are widely used to flavor the food preparations. Total 3 spices samples were divided into many groups and processed by sun drying, cabinet drying, shade drying, added different preservatives added by paste spices. Then quality changes were evaluated based on physicochemical parameter, proximate analysis, mineral contents (Na, K, Ca, Mg and Fe), vitamin content (vitamin C and β-carotene), microbiological analysis and sensory evaluation. The physicochemical parameter such as TSS, pH and acidity varied from 6ºB to 43ºB, 4.86% to 5.1% and 1.21% to 0.51% respectively. The proximate composition such as moisture, ash, protein, fat, fiber and carbohydrate varied from 3.96% to 85.69%, 0.82% to 1.0%, 1.63% to 5.81%, 1.03% to 1.77%, 1.26% to 3.27% and 11.16% to 4.3% respectively. The vitamins C and β-Carotene content are 2.27mg/100g to 3.00mg/100g, 49µg/100g to48µg/100g and minerals content Na, K, Mg, Ca and Fe content are 12.97mg/100g to 9.87mg/100g, 45.75mg/100g to 39.93mg/100g, 40.33mg/100g to 11.2mg/100g, 15.57mg/100g to 8.01mg/100g, 0.53mg/100g to 0.65mg/100g respectively. The total plate count (TPC) value of fresh ginger, garlic and green chili were found 2×10^4, 33×10^4, 5.27×10^4CFU/g. There was no colifroms found in any of fresh and processed spices that were analyzed. The overall acceptability of the sensory characteristics varied from 8.26 to 5.6. Result showed that processing and preservation method had significant effects on the quality of the different spices ($p<0.05$).

Key words: Spices, Processing, Preservation, Quality.

Chapter 1: Introduction

Bangladeshi spices include a variety of spices that are grown across south and Southeast Asia. Many of the spices are native to the region, while the others were imported from similar climates and have since been cultivated locally for centuries.

The term spice thus used to cover the use of spices, herbs and certain aromatic vegetables to impart odor and flavor to foods. Spices are not just valuable in adding flavor to foods they are also used in medicine, cosmetics, religious rituals, perfumery and as preservatives. According to ISO's recent report there are about 109 spices grown in different parts of the world in different climatic conditions. India produces about 75 varieties of spices in its various agro-climatic conditions.

Spices are obtained from different parts of the spice plants. The important spices are ginger, garlic, turmeric, sarsaparilla, angelica, and asafetida obtained from rhizome; cinnamon and cassia obtained from bark; clove, capers and saffron obtained from flowers; coriander, dill, fennel, pepper, cumin, green chili, vanilla, anise, caraway obtained from fruits; mustard, cardamom, fenugreek, nutmeg, joyphal obtained from seeds; and basil, marjoram, coriander leaf, peppermint, Indian cassia and lemon grass obtained from leaves. A good number of spices are cultivated and used in almost all preparation of food. Yet a large number of spices are imported from India, Malaysia and Indonesia. The commonly cultivated spices in Bangladesh are ginger, garlic, turmeric, onion, red pepper, coriander, Indian cassia, peppermint, etc. The young coriander plant is commonly used as a flavoring or a savory for vegetable and fish curry preparations. Chili, garlic, ginger, coriander, cumin and some other spices are most popular in Bangladesh. During 1998-99 the total production of various spices and condiments in Bangladesh was 3,95,150 tons under the cultivated area of 6,21,075 acres (BBS,1999). Garlic, onion, turmeric and others are always preferred due to their original flavor and pungency than the dried powders. However, these pastes must be used fresh and these deteriorate quickly at room temperature under Bangladesh condition. Moreover, preparation of these pastes is time consuming and laborious.

The area and production of spices and condiments during 2004-05 were respectively about 23,617 ha and 23,865 m tons (BBS, 2005). During 2013-14 the total production of various spices and condiments in Bangladesh was 20,41,785 metric tons under the

cultivated area of 8,55,430 acres (BBS,2014). During 2014-15 the total production of various spices and condiments in Bangladesh was 24,08,263 metric tons under the cultivated area of 9,24,280 acres (BBS,2015). During 2016-17 the total production of various spices and condiments in Bangladesh was 26,74,470 tons under the cultivated area of 10,18,278 acres (BBS,2017).

Food and Agriculture Organization (FAO) defines “spices” as vegetable products such as leaves, flowers, seeds and roots that are rich in essential oils and aromatic principles. The spices are commonly used as condiments or employed for other purposes on account of their fragrance, preservative or medicinal qualities. India, known as ‘home of spices’, produces about 75 spices in its varied agro-climatic regions and has emerged as one of the largest producer, consumer and exporter of spices in the world. More than 90 per cent of the spices produced in the country are used to meet domestic demand and India contributes about 44 per cent of total value of the world spices trade. This shows a huge domestic market and trade potential for spices products in the country.

Spices are important flavoring components in the dietaries of several countries particularly in Asia, Africa and Europe. Several spices including chili, black pepper, nutmeg, cinnamon, ginger, and turmeric are important in World trade (Mohan et al., 2013). .According to Code of Hygienic Practice for Spices and Dried Aromatic Plants (CAC/RCP 42-1995) spices are defined as follows: “The term spices, which includes dried aromatic plants, relates to natural dried components or mixtures thereof, used in foods for flavoring, seasoning and imparting aroma”. The term applies equally to spices in the whole, broken or ground form”(Codex, 1995).Consumption of spices is generally higher in Asian countries such as India, China, and Thailand. However, there has been an increasing trend in their intake in developed countries such as in Europe and the USA, because of changing food habits and preference for ethnic and spicy food (Williams, 2006; CBI Ministry of Foreign Affairs, 1999).

The Geneva based International Standards Organization (ISO) defines Spices and Condiments as: Vegetable products or mixtures thereof, free from extraneous matter, used for flavoring, seasoning and imparting aroma in food.

Spices as products which enricher alters the quality of a thing, for example altering the Taste of a food to give it zest or pungency, a piquant or lasting flavoring, or a relish (Rosengarten, 1973).

1.1 Significance of the study

Fresh spices are perishable in nature and the major causes of spoilage are improper handling, growth of spoilage microorganisms, action of naturally occurring enzymes, chemical reactions and structural changes during storage. The postharvest losses of ginger are high but could be considerably reduced if it is properly stored and processed immediately after the harvest. Ginger can be used to produce processed and semi-processed products such as powder, flakes, candy, ready to serve beverages, paste, etc. Drying of ginger has the limitation in that the volatile oils and chemical compounds responsible for pungent flavors, especially gingerols and pigments, are highly heat sensitive (Baranowski, 1985; Pezzutti & Crapiste, 1997).

Therefore, there is an urgent need to explore alternate processes for the preservation of ginger and to develop products based on these. Ginger paste is one such alternate product and can be stored for long periods without much alteration of the freshness of the material and can also be considered as a minimally processed food (Baranowski, 1985; Ahmed & Shivhare, 2001; Ahmed et al., 2002).

Ginger paste is a viscous product retaining the strong aroma and flavor of the raw material namely fresh ginger. The volatile oil content in the product is influenced by factors such as variety, raw material storage, handling and processing conditions. The product is generally creamy- white or off white in color the product is microbiologically stable and free from pathogenic bacteria.

Importance of ginger is well known and its medicinal, nutritional and commercial values have been reported by many researchers. One hundred grams of edible ginger contain approximately 9 g protein, 6 g fiber, 116 g calcium, 71 g carbohydrate, and 147 IU of Vitamin A (Farrell, 1999). Ginger is known to contain many powerful antioxidants. It is good for the gastric system and increases digestive enzyme activity; it is known to cure motion sickness, upset stomachs, headaches, congestion, and lowering fevers when added to the bath water. Other benefits include cleansing of the colon, reducing spasm and cramps, stimulating circulation, and aiding the

metabolism, stress relief, and the increased circulatory response, which raises oxygen levels. It also helps in minimizing joint pain from arthritis and other inflammatory disorders.

Dry ginger is utilized for the manufacture of ginger powder and several other by products such as ginger oil, ginger essence, ginger oleoresin and soft drinks. It is also used as a flavoring material in food products. It is experimentally proved that dry ginger yields more ginger oil (volatile) and oleoresin as compared to fresh ginger (Damayanti et al., 1983).

In general drying of ginger (peeled and unpeeled) is indigenously performed under sun. This is a very time consuming method and the method produces the inferior quality of the product. In order to reduce the time of drying and to obtain a good quality final product, mechanical dryers that use heated air are mostly employed for drying ginger now a days. Besides giving a better quality product, it also avoids the dependency on the vagaries of weather and reduces microbial contamination of the product.The effect of various methods of dehydration on the quality of garlic powder and suggested that the dehydrated garlic may be ground into powder. They that freeze drying and vacuum shelf drying produced better quality product in respect of Colorthan that produced by hot-air drying or sun drying, however, no significant difference was noticed in respect of flavor and antimicrobial properties. They further developed a technique in which garlic bulbs were carefully cracked and the segments separated by hand. The segments were then given a mechanical treatment and subjected to hot air drying (Pruthi et al., 1959).

The effect of three methods of drying (open sun drying, shade drying and by means of a solar drier) on cauliflower, with or without blanching, on the quality of the dried product. All dried samples were analyzed for proximate composition, ascorbic acid, water-soluble sugar, tryptophan, iron, phosphorus, sodium, potassium, and calcium. Result showed that blanching followed by solar drying produced the shortest drying time, best organoleptic properties and the lowest nutrient losses (Goyal and Mathew, 1990).

Garlic is cultivated during the rabi season in Bangladesh. In 2014-15, nearly 3,45,725 metric tons of garlic bulbs were produce in Bangladesh 1,40,975 acreage of land (BBS,2015). The average yield is only 24.52 per acre yield (mt).

Garlic is used practically all over the world for flavoring various dishes. In America, about 50% of the entire output of fresh garlic is dehydrated and sold to food processors for use in mayonnaise products, salad, dressings, and tomato products and in several meal preparations. Furthermore, raw garlic can be used in the manufacture of garlic powder, garlic salt, garlic vinegar, garlic cheese, garlic potato chips, garlic bread and meat-tit-bits and garlicked bacon etc. Which have been boosted in the America marked. It is also being used in several food preparations notably in chutneys, pickles, curry powders, curried vegetable, meat preparations, tomato ketchup and the like (Pruthi, 1998).

Garlic acts as a popular remedy for various ailments and physiological disorders. Application of garlic in Ayurvedic and Unani medicines in the treatment of diseases like chronic infection of the stomach and intestine, dysentery, typhoid, cholera and diseases of lungs is well known (Chopra et al., 1958). Aqueous extracts of garlic cloves (allicin and related disulphide) significantly reduce cholesterol level in men (Augusti, 1977).

Garlic oil is an insecticide an antibiotic. Garlic juice is used for various ailments of the stomach, as a rubefacient in skin disease and as ear drops in earache. In cancer, influence of garlic antibiotic on malignant tumours of humans as well as animals has been found useful. Garlic contains allicin, which makes it an antioxidant, antibacterial and antibiotic (Augusti, 1976) and is also responsible for the typical garlic flavor.

In order to estimate the dietary intake of garlic per person per month and to record three blood pressure reading on each individual. The various demographic parameters including age, sex, marital status and education were recorded. Those subjects found to be overweight, with a known history of hypertension, diabetes mellitus, heart diseases, and smoking and on medications which affect blood pressure, were excluded from the study to remove the effect of confounding variables on blood pressure. An average garlic use of 134g per month was found; 67% of the subjects used garlic in cooked food while the rest used it either in the raw from or in pickles; 59% through that the dietary use of garlic is healthy. Subjects with blood pressure on the raw side were found to consume more garlic in the diets (statistically significant for systolic blood pressure only) (Waris-Qidwai et al., 2000).

Possible health effects of garlic (*Allium sativum*) are discussed with reference to traditional health benefits of garlic, active ingredients, possible links of garlic with health benefits of the Mediterranean diet; possible hypo-cholesterolaemic action of garlic; possible blood pressure lowering action and the small number of high quality studies on health effects of garlic (Beaglehole, 1997).

Chili (*Capsicum spp.)* is an important commercial spice and vegetable crop for small and marginal farmers in Asia, Africa and South America. Among the 5 cultivated species of the genus Capsicum, C. annuum is the most widely cultivated in India for its pungent (chili syn. hot pepper) and non-pungent (sweet pepper syn. capsicum, bell pepper) fruits.

Green chilies are rich source of Vitamin A and Vitamin E. It is widely used in the curry powder, curry paste, all kinds of pickles and preparing sauce, soups, etc. The quality of dried chili is assessed by a number of different parameters such as color, hotness, ascorbic acid content and volatile flavor compounds (Henderson, 1992; Ruth et al., 2003; Jiang and Kubota, 2004; Kim et al., 2006; Wang et al., 2009).

Chili market types prevalent in India can broadly be grouped into the following 4 categories: (i) fresh market (green, red, multi-color whole fruits), (ii) fresh processing (sauce, paste, canning, pickling), (iii) dried spice (whole fruits and powder), and (iv) industrial extracts (paprika oleoresin, capsaicinoids and carotenoids). Besides conventional nutritional food uses, a number of versatile food (paprika oleoresin) and non-food (defense, spiritual, ethnobotanical) uses of chilies are known (Kumar et al., 2006; Meghavansi et al., 2010).

Green chili has the higher demand than the red chili. In season the price of green chili is reasonable having Rs. 2535 per kg but in off season, the market rises up to Rs. 50-60 per Kg. The preservation of green chili is very difficult due to its perishability; it is subject to quick deterioration during storage, transportation, and marketing. Huge amount of green chili found to be wasted in the field for the lack of proper processing and preservation technology (Shanmugavelu, 1989).

Green chili paste (GCP) is a traditional food from the northern part of Thailand. In a large local market it is not unusual that about 500 kg/day of GCP are sold. GCP is made from chili, red onion and garlic. Chili (Capsicum annuum Linn.) is a rich source

of phenolics and a good source of flavonoids, which of late have aroused great interest owing to their antioxidant activities. Red onion (Allium ascalonicum Linn.) and garlic (Allium sativum Linn.) are widely used vegetables in diets around the world. The antioxidant activity of Allium plants has mainly been attributed to a variety of sulphur-containing compounds and their precursors (Ferreres et al., 1996; Nuutila et al., 2003; Yoo et al.,1998).

1.1 Aim of the study

The overall aim of the study is to compare the effectiveness of different processing and preservation methods on quality of different spices such as ginger, garlic and green chili.

1.2 Specific objectives of the study

1. To prepare ginger, garlic, green chili powder and paste in different preservatives concentration from fresh ginger's, garlic's, green chili's powder and paste in different preservative concentration from fresh;
2. To determine physicochemical parameter (TSS, TA, pH); proximate composition; vitamin (Vitamin C and β-Carotene) content; mineral (Na, K, Ca, Mg and Fe)content of ginger, garlic, green chili powder and paste in different preservative concentration;
3. To determine microbial changes of ginger, garlic, green chili powder and paste in different preservative concentration;
4. To determine sensory characteristics of ginger, garlic, green chili powder and paste in different preservative concentration.

Chapter 2: Review of Literature

2.1 Food Processing and Preservation

Processing and Preservation of horticultural produce such as fruits, vegetables, spices, etc, assume a key position in the agro-industrial developmental plans of the country. Horticultural based processing industries can stimulate the commercial growers to cultivate high quality crops for better economic returns to generate, in turn, enormous employment opportunities in production sphere of activities.

Processing and preservation of horticultural produce have multiple objectives, of which extending the consumption period, value addition and the possibility of diversification to range of products suiting to consumers' preference are the prime one. The basic preserving processes are canning, freezing, drying, salting, pickling a1nd freeze-drying. Processing can help fresh produce to change into new or more useful forms and make it more convenient for preparation and consumption. Various processing and preservation techniques evolved, developed and now being gradually adapted for horticulture industries.

Food preservation involves the action taken to maintain foods with the desired properties or nature for as long as possible (Rahman, 2007). Preservation methods start with the complete analysis and understanding of the whole food chain, including growing, harvesting, processing, packaging and distribution; thus an integrated approach needs to be applied. It lies at the heart of food science and technology, and it is the main purpose of food processing.

2.2 Food Processing and Preservation Method

Processing and preservation methods start with the complete analysis and understanding of the whole food chain, including growing, harvesting, processing, packaging and distribution; thus an integrated approach needs to be applied. It lies at the heart of food science and technology, and it is the main purpose of food processing.Based on the mode of action, the major food preservation techniques can be categorized as (1) slowing down or inhibiting chemical deterioration and microbial growth, (2) directly inactivating bacteria, yeasts, molds or enzymes, and (3) avoiding recontamination before and after processing. A number of techniques or methods from the above categories are shown in Figure (Gould, 1989,1995).

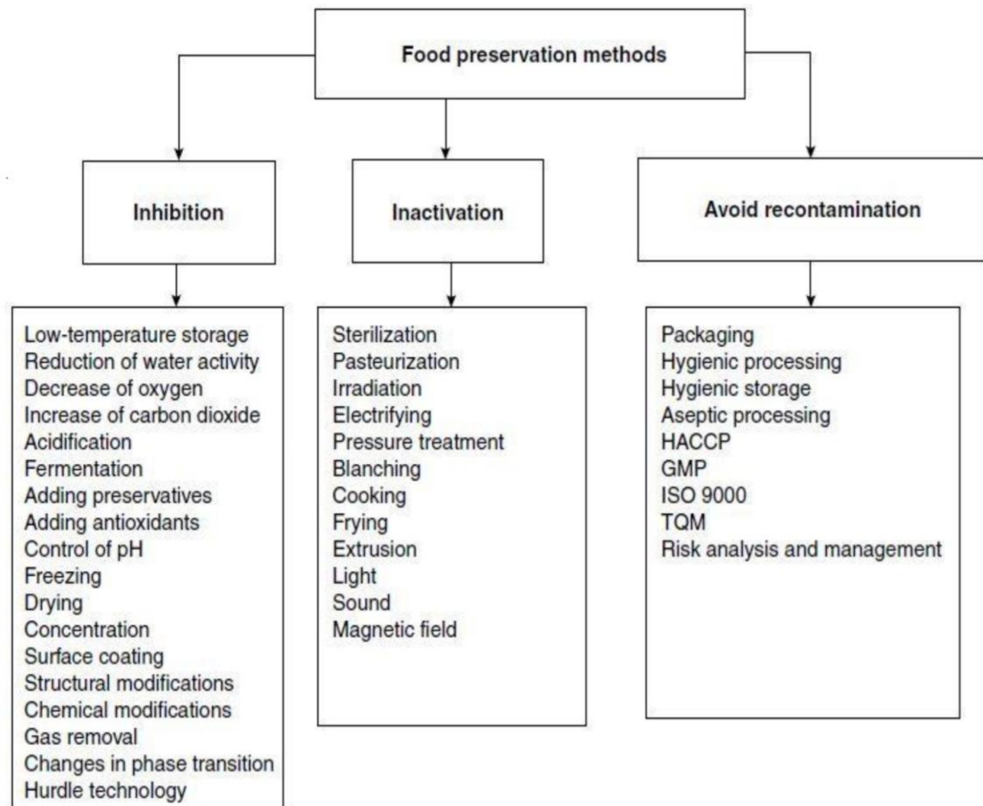


Figure 2.1: Major food preservation methods (Gould, 1989,1995).

2.3 Classification of Spices

According to ISO's recent report Spices are important group of agricultural commodities, because of their Taste and aroma they are widely used to flavor the food preparations, Spices do not have much nutritive value but the importance of Spice in daily diet is due to the fact that they enhance the aroma and flavor of food preparations. There is lot of heterogeneity found with respect to the plant parts used. India is one of the largest producers of Spices and condiments. India is one of the major contributor to the total world trade. The classification of the Spices and medicinal plant samples is mainly based on morphology and the plant part which is used for the purpose. The workers from the different parts of the world worked on mycobiota and mycotoxins analysis of different Spices and other commodities from various parts of the world. There are about 109 Spices grown in different parts of the world. These Spices can be classified by a number of criterion. Two of the most popular ways of classifying spices are:

1. Classification based on Degree of Taste:

2. Classification based on Plant Organs:

The various spices under the above two classifications are given in Table 2.2 and Table 2.3

Table 2.1` Classification of Spices by Taste

Classes	Spices
Hot Spices	Pepper, Chili, Ginger, Mustard
Mild Spices	Coriander, Paprika
Aromatic Spices	Pimento, Cardamom, Cassia, Cinnamon, Cumin, Clove, Dill, Fennel, Fenugreek, Mace, Nutmeg.
Herbs	Basil, Bay, Dill leaves, Maijoram, Thyme
Aromatic vegetables	Onion, Garlic, Celery, Shallot.

Source: Ravindran et al., (2006)

Table 2.2 Plant Organs as Spices

Plant organs	Spice crops
Seeds	Ajowan, Aniseed, Caraway, Celery, Coriander Cumin, Fennel, Fenugreek, Mustard, Poppy Seeds.
Leaves	Basil, Tejpat, Curry leaves, Mint, Chives, Spearmint, Thyme leaves, Parsley.
Flowers	Rose, Caper, Saffron
Fruits	Cardamom, Chili, Kokam, Mace, Tamarind, Nutmeg Anise, Vanilla
Roots	Garlic, Ginger, Onion, Turmeric, Galangal
Bark	Cinnamon, Cassia, China.
Miscellaneous	Black Pepper, White pepper, Clove, Asafetida, Tejpat, Arrow root.

Source: Ravindran et al., (2006)

2.4 Nutritional value and properties of ginger

Ginger is very important commercial crop grown for its aromatic rhizomes which is used both as a spices and medicine. Its scientific name is *Zingiber officinale Roscoe.* In Bangali it is called Ada. Ginger is valued for the dried ginger spice and preserved, crystallized ginger. Ginger is a perennial plant but is usually grown as an annual for harvesting as a spice. Ginger is best grown in partial shade and can be incorporate as an intercrop in coconut, coffee and orange plantations. Ginger possesses a warm pungent Taste and a pleasant odor, hence it has a wide use as a flavoring in numerous food preparation, beverages, ginger bread, soups, pickles and many soft drinks. There are two general types of ginger viz. fresh green ginger used for the preparation of candied ginger (in sugar syrup) and dried or cured ginger applied in the spice trade, for extracts, oleoresins and for the distillation of its volatile oil.Fresh ginger contains 80.9% moisture, 2.3% protein, 0.9% fat, 1.2% minerals, 2.4% fiber and 12.3% carbohydrates. The minerals present in ginger are iron, calcium and phosphorous. It also contains vitamins such as thiamine, riboflavin, niacin and vitamin C. The composition varies with the type, variety, agronomic conditions, curing methods, drying and storage conditions (Gugnani, 1985).

Ginger powder is rarely used in its pure form but it is an important ingredient of curry powder. It is also used in ginger wine, ginger beer and baked goods. Ginger powder can be found after grinding the dry ginger. So for ginger powder the main raw material is dry ginger. Ginger powder can be used as pharmaceuticals and used for the production of herbal medicines. It also used as food additive. Ginger powder also has a very good export market (Richardson, 1966) Richardson (1966) carried out research on ginger dehydration in Australia. He concluded that 57 3°C was the highest temperature at which ginger can be dried for spice market and for extraction purposes the temperature up to 83°C can be used.

Thin layer drying experiments on the Siliguri variety of ginger to study its drying characteristics and evaluated the quality of the dried product by determining its volatile oil and oleoresin content. They also designed a small capacity tray dryer. The evaluation of the dryer showed that the performance was satisfactory at an air temperature of 60°C which was also found to be most suitable temperature for drying ginger slices (Bhuyan and Prasad, 1990).

Fresh ginger is perishable in nature and the major causes of spoilage are improper handling, growth of spoilage microorganisms, action of naturally occurring enzymes, chemical reactions and structural changes during storage. The postharvest losses of ginger are high but can be substantially minimized by processing and proper storage immediately after harvest. Though, ginger can be used to produce processed and semi-processed products such as powder, flakes, candy, ready to serve beverages, paste, etc.(Baranowski, 1985; Pezzutti & Crapiste, 1997).

But, there is an urgent need to explore alternative processes for its preservation along with value added products. Ginger paste is an alternate product that can be stored for long period without much alteration of its freshness and can also be considered as a minimally processed food (Ahmed & Shivhare, 2001; Baranowski, 1985).

This paste is mainly used as a spice in culinary preparations for imparting a typical fresh ginger flavor. It is a ready to use preparation that substitutes fresh ginger in homes, restaurants and institutional catering. Chemical preservatives such as sodium metabisulfite (0.5% w/w), citric acid (0.2% w/w), sodium benzoate (0.015% w/w) and sodium chloride (1.5% w/w) are generally used to increase the shelf life of ginger paste (Akhtar et al., 2015).

Recently, the market for spice pastes has increased significantly mainly because of the success of fast food industries and restaurants. However, the technologies of proper storage and preservation of ginger paste are often not available to the small scale processors, for which the ginger produced in small scale industries often cannot compete with the major brands available in the market. Further, the type of packaging and storage conditions often do not match the requirements of the paste, and hence, the quality of the paste deteriorates during storage. There are also degradation of color, and other parameters limiting its shelf life and use. Study of changes in physico-chemical properties such as pH, TSS, TS, acidity, water activity, etc. as affected by the different storage conditions are important for deciding the effective shelf life of the paste and thus for recommending a suitable packaging method to the entrepreneurs. Also, change in color and increased browning during processing and storage of processed foods are influenced by many factors like pH, acidity, storage temperature and duration etc. (Garcia et al., 1999).

The effect of pre-treatment and storage conditions on the quality characteristics of ginger paste. Ahmed (2004) reported that ginger paste at 5 (±1) °C temperature in polyethyleneterephthalate or glass containers can be stored for 120 days. Unni, Chauhan and Raju (2015) worked on high pressure processed ginger paste under refrigerated storage and concluded that the paste treated with 600 MPa pressure for 5 min could extend shelf life for 6 months under low temperature (80–85% RH) storage keeping the vital phytonutrients, organoleptic and microbiological properties for commercial applications(Choi et al.,2012).

Concluded that ginger garlic paste treated with microwave heating was more shelf stable compared to that treated with simple heating during storage for 3 months.

Table 2.3 Nutritive value of Ginger (*Zingiber officinale Roscoe*) per 100gm

Nutrients	Nutrient value
Energy	80 kcal
Carbohydrates	17.77 g
Dietary Fiber	2 g
Total Fat	0.75 g
Protein	1.82 g
Thiamin (B-1)	0.025 mg
Riboflavin (B-2)	0.034 mg
Niacin (B-3)	0.75 mg
Pyridoxine (B-6)	0.16 mg
Folates (B-9)	11 µg
Vitamin C	5 mg
Vitamin E	0.26 mg
Calcium	16 mg
Iron	0.6 mg
Potassium	415 mg
Sodium	13 mg
Magnesium	43 mg
Zinc	0.34 mg
Phosphorus	34 mg
Moisture	79 g

(Source: United States Department of Agriculture National Nutrient data base, 2018)

2.5 Nutritional value and properties of garlic

Garlic needs no introduction since it has been recognized all over the world as a valuable condiment for foods, and a popular remedy or medicine for various ailments and physiological disorders. Its scientific name is *Allium sativum Linn*. In

Bangali name is Rashun. Garlic has since long been cultivated particularly throughout Bangladesh as an important minor spice or condiment crop. Garlic (*Allium sativum L.)* is liliaceous biennial herbaceous plants underground of garlic, spicy Taste, strong garlic smell (Shan et al., 2013). Fresh peeled garlic have the composition of moisture. 62.8%; protein, 6.3%; fat, 0.1%; ash, 1.0%; vitamin C, (mg/100g sample) 13%; fiber, 0.8%; carbohydrates, 29.0%; calcium, 0.03%; phosphorus, 0.31%; iron (Fe), 0.001%; calorific value 142kcal/100 (food energy); nicotinic acid, 0.4mg/100g; (Pruthi,1998) . The proximate composition and nutritive value of dehydrated garlic is moisture, 5.2; protein, 17.5%; fat, 0.6%; mineral matter 3.2%; fiber, 1.9%; carbohydrates, 71.4%; calcium, 0.1%; phosphorus, 0.42%; iron, 0.004%; sodium, 0.01%; potassium, 1.1%; vitamin C, 12.0 mg/100g; calorific value (food energy), 380 calories /100 (Pruthi, 1998). Leung et al. (1972) reported the chemical composition of various pastes made from chili, ginger, coriander, cumin, mustered seed, garlic, onion, turmeric and other spices.

Kim and lee (1996) stored green peppers for 35 days at 3°C and 25°C and investigated the contents of capsaicin, ascorbic acid, chlorophyll, free sugars and surface color values. Isidoro et al., (1995) studied the effects of pod maturity, time of harvest and length of storage on the color stability of red chili powder.

Sasaki et al. (1999) informed that the antibacterial activity of garlic powder against 0-157 was tested by using garlic bulbs post-harvested 1 y. 0-157 at 106-7 of cfu/mL perished after incubation for 24 h with a 1% solution of garlic powder. The use of powder from fresh garlic was more effective for antibacterial activity than from old garlic; the 1% solution of fresh garlic powder eradicating the 0-157 in 6 h. The antibacterial activity was resistant to heat treatment of 100º C for 20 min. The water-soluble components of garlic powder were fractionated into three fractions (Fr. 1-3)

by Sephadex G-100 column chromatography, among which Fr. 3 showed antibacterial activity against 0-57 but the other fractions were scarce in activity. The antibacterial activity was also shown against other types of pathogenic bacteria such as methicillin-resistant Staphylococcus aureus (MRSA), Salmonella enteritidis, and Candida albicans. Thus, the practical use of garlic powder is expected to prevent bacteria-caused food poisoning.

Charles et al., (1992) observed that in the Ayurveda and Sidha system of traditional Indian medicine, neem and turmeric have been used for haling chronic ulcers and scabies. A study was conducted in Tamil Nadu of the efficacy of both plant products formulated as a paste (fresh neem and turmeric have been used for healing chronic ulcers and scabies. A studies was conducted in Tamil Nadu of the efficacy of both plant turmeric formulated as a paste (fresh neem leaves andturmeric in the proportion 4:1 by weight) for the treatment of scabies [caused by Sarcoples scabiei] in 814 people. In 97% of cases a cure was obtained within 3 to 15 days of treatment. This is considered to be a very cheap, easily available, effective and acceptable means the treatment for villagers in developing countries. No toxic or adverse reaction has been noticed so far, although further research in needed to evaluated safety aspects of use.

Pereira et al (1998) stated that turmeric is widely used as a natural food coloring and spice, and as a therapeutic in Indian medicine system. The plant is native in Southern, Asia, China, the Caribbean and South America. A review is presented of the use of turmeric as a natural food coloring, including information on the following aspects; toxicology; processing; pigment extraction; stability; analytical method for evaluation of turmeric and commercial use.

Thai garlic has many good properties, such as deliciousness, pungency purity, crispy and tasty product, mildew resistance, rot-fastness, storable character and high nutritive value. It has been widely used around the world for its characteristic flavor as a seasoning or condiment. Garlic is a rich source of phytonutrients, hence contributing to treatment and prevention of a number of diseases, such as cancer, obesity, cardiovascular diseases, diabetes, hypercholesterolemia, and hypertension (Pardo et al., 2007).

Drying is an alternative to minimize the losses to the considerable volatile and active compounds. Garlic cloves with approximately 1.85 g water/g dry matter are dried to a

safe moisture content of 0.06 g water/g dry matter. Currently hot air drying method is used for drying the garlic (Papu et al., 2014).

Table 2.4 Nutritive value of Garlic (*Allium sativum Linn)* per 100gm

Nutrients	Nutrient value
Energy	149 kcal
Carbohydrates	33 g
Dietary Fiber	2.1 g
Total Fat	0.5 g
Protein	6.36 g
Thiamin (B-1)	0.2 mg
Riboflavin (B-2)	0.11 mg
Niacin (B-3)	0.7 mg
Pyridoxine (B-6)	1.24 mg
Folates (B-9)	3 µg
Vitamin C	31.2 mg
Calcium	181 mg
Iron	1.7 mg
Potassium	401 mg
Sodium	17 mg
Magnesium	25 mg
Zinc	12.16 mg
Phosphorus	153 mg
Moisture	59 g

(Source: United States Department of Agriculture National Nutrient data base, 2018)

2.6 Nutritional value and properties of green chili

Chilies are natures wonder. Its fruit appear in different sizes, shapes and colors. For characteristics of chili cultivars, soil, climate, cultivation condition, natural hybridisation and selection play important role in differentiation of shape, size, color, pungency and aroma. Its scientific name is *Capsicum annum Longum*. In Bangali name is Kacha morich/ kacha lonka. Chilies (*Capsicum annuum L.*) are extensively consumed throughout the world because of their color, flavor and pungency. It is a unique spice-cum-vegetable with a commercial value. Chilies are important spice used in culinary, pharmaceutical and beverage industries across the globe. The history of pepper plant in European cuisine is accompanied by an enumeration of the capsaicin which gave the hot flavor to make a valuable food (Siviero et al., 2001).

Chili fruits of high quality were large in size heavy in weight and contained higher sugar capsainthin but low content of capsaicin (Hwang and Chung, 1998).

Chili has high concentration of vitamin A, C and E the oxidative vitamins (Osuna Garcia et al., 1998).

Fruit composition varies considerably among the cultivars due to seasonal conditions and maturity at harvest. Fresh fruit contains 0.1 to 2.6 per cent of steam-volatile oil, fixed (fatty) oil of 9 to 19 per cent, pigments, pungent principles resin, protein at 12 to 15.5 per cent, cellulose pentasons and minerals. Fresh fruits are rich sources of vitamin C and an important source of vitamin A (Howard et al., 1994).

Nutritional composition vary in chilies from variety to variety (Kaur et al., 1980) and also location to location (Raina and Teotia, 1985; Teotia and Raina, 1986).

The composition of a variety of *Capsicum annum L.* (Longum) species which were extensively cultivated in Galicia (N.W. Spain). After moisture, insoluble fiber was the abundant component found in the fruit. Non-digestible fiber was 2.2 g per 100 g of fresh weight and vitamin C recorded 0.24 mg per 100 g (Lopez-Hernandez et al., 1996).

Table 2.5 Nutritive value of Chilies (*Capsicum Annuum Longum*) per 100gm

Nutrients	Nutrient value
Energy	160 kcal
Carbohydrates	8.8 g
Dietary Fiber	1.5 g
Total Fat	0.4 g
Vitamin A	48 µg
Beta-carotene	534 µg
Pyridoxine (B-6)	0.51 mg
Vitamin C	144 mg
Iron	1 mg
Potassium	322 mg
Magnesium	23 mg
Moisture	88 g

(Source: United States Department of Agriculture National Nutrient data base, 2018)

2.7 Effect of processing and preservation of ginger, garlic and green chili

The ginger rhizome has been used in traditional systems of medicine for centuries and more recently, its potentially medicinal properties have been empirically studied (Chrubasik et al., 2004). Current research suggests that the active constituents of ginger, namely the gingerol and shogaol classes of compounds, might exert several beneficial effects including anti-inflammatory, antioxidant, and cholesterol lowering properties (Chrubasik et al., 2004). In addition, ginger is apromising treatment for nausea associated with a variety of stimuli including post-operative nausea andvomiting, motion sickness, morning sickness, and chemotherapy-induced nausea and vomiting (Marx et al., 2003; Chaiyakunapruk et al., 2006; Thomson et al., 2014 and Lien et al.,2003)

Dehydration is one of the oldest and efficient methods of food preservation. This is a form of drying by artificially produced heat under carefully controlled conditions of temperature, humidity and air flow (Cruess, 1958). The basic objective of drying food

products is to remove free water to a level where microbial spoilage is reduced and shelfstable and less perishable product is ensured (Gorjiae et al., 2011). Ginger (*Zingiber officinale var.* 'Grand Cayman') has been extensively used as a traditional medicine in the East, however the high moisture content (70-75%) of ginger makes it susceptible to microbial contamination and insect infestation, resulting in significant loss and deterioration of product quality. Conventional drying method reduces the moisture content and increases the shelf life of the product; but it often results in loss of nutrients and has an adverse effect on the flavor and appearance (color) of the product. Therefore, osmotic dehydration may provide an option for removing water without any adverse effects on food (Santagpita et al., 2013 and Silva et al., 2014).

Fresh ginger suffers from weight loss, shrinkage, sprouting and rotting during storage after 3 to 4 weeks of harvesting. This spoilage can be overcome by processing fresh produce to some value added products (Nath et al. 2013). The various value added products prepared from ginger are ginger oil, oleoresin, ginger candy, ginger preserve, ginger puree, ginger powder, ginger beer and ginger paste (Arya, 2001; Camacho and Brescia, 2009 and Altman et al. 2001). According to Okafor and Okafor (2007) dried ginger whole and powdery form is used for preservation of meat, soups and puddings. Most of the world's ginger is processed into concentrates for the manufacture of ready - to- serve ginger drinks which can be alcoholic or non alcoholic. Appearance, pungent principles, fiber, aroma and flavor characteristic of volatile oil are important in the quality evaluation of dried ginger (Ebewele and Jimoh, 1988).

Kim (1998) studied the mass transfer characteristics during the osmotic drying of ginger and its effect on quality. He found that the moisture loss during osmotic drying (using sugar solution at 60°Brix at 80°C with 18 min immersion time) was 40.05 g moisture per 100 g wet ginger which was equivalent to a 52 per cent reduction of initial moisture content of ginger (83.02% wb). It was also observed that the osmotically dried ginger softened more quickly than blanched ginger in boiling water.

Rodriguez (1971) examined the color of dried ginger treated with calcium oxide solution. He applied the process of steeping peeled ginger in plain water for 2 hours and then steeping with 1.5 to 2 per cent Calcium Oxide (lime) solution for 6 hours. He reported that pre-treatment of lime with ginger improved the color of the dried product. Raina et al. (1988) conducted experiments on dehydration of six varieties of

white onion to study their quality characteristics. It was reported that the rehydration ratio ranged from 1: 5.17 to 1: 6.17 for the onion slices of 3.5 mm thickness dried in cross flow dryer at 60°C for 6 hours.

Yoontee el al. (1995) studied the effects of drying conditions of ginger and storage methods of ginger powder on the qualities. They employed solar energy and hot air at temperatures 35, 50 and 65°C and investigations of the study indicated that drying of ginger in the sun improved its quality but took longer time than drying in hot air. It also stated that as hot air temperature was increased, browning of ginger slices was also increased. The conclusion was that sun drying was better than hot air drying based on the sensory tests of color, flavor and Taste of ginger powders.

Yoontee (1995) observed that the pre treatment of sodium metabisulphite reduced browning and destroyed micro organisms in dried ginger.

Topno et al. (2011) conducted a study on ginger-garlic paste in which ginger paste was made after breaking the rhizomes into pieces to expose the crevices and then washed in running water to remove the adhering mud. Again the cleaned rhizomes were scraped with a knife to remove dirt as well as spoiled portion. Ginger rhizomes were soaked in potassium metabisulphite solution (1 g/L) for 12 h and washed thoroughly; rhizomes were peeled using a vegetable peeler. The peeled rhizomes were passed through a hammer mill fitted with 30 mesh (500 mm) to get a fine paste. Ahmed (2004) prepared ginger paste by adding common salt at 8% (w/w) to ginger puree to increase its total soluble solids (TSS). Fresh ginger puree had a pH of 6.38 and was adjusted to 4.05 by adding 30% citric acid solution (w/v). It has been established that an acidified food ($pH < 4.6$) requires only pasteurization (Garcia et al., 1999) to retain its fresh spice odor.

Paste is characterized as the product obtained after addition of common salt and organic acid to the puree (Ahmed & Shivhare, 2001). Thus, Ahmed et al. (2004) converted coriander puree to paste by addition of 2% sodium chloride (w/w) and the required volume of 30% (w/v) citric acid to adjust the pH to approximately 4.2. Salt level was selected by a preliminary sensory test. Salt increased total soluble solids of puree. After pasteurization at 800C for 15 min the paste was hot-filled into presterilized glass bottles. The bottles were cooled by spraying chilled water and stored at selected temperatures (5, 25 and 37±1ºC) for 6 months.

Baranowski (1985) studied odor change and changes in color and flavor components of ginger paste. To evaluate odor changes, cans that are filled with ginger paste were stored at either -100 or 25°C. The pastes were sampled at 0, 4, 8, 16 and 24 week of storage. The 0 week stored samples were evaluated immediately after their preparation. Odor was evaluated by a 10 member trained panel. In the second study, to evaluate changes in color and flavor components, samples were stored at -100, 100, 250and 37°C. Color was monitored by Hunter color difference meter values. Samples were taken at the same time interval as in the first study. Ahmed (2004) processed ginger paste at 800C for 15 min and packed immediately in containers viz. glass, polyethylene terephthalate (PET) or a highdensity-poly-ethylene (HDPE) pouch. Paste was stored at 5 ± 1° and 25 ± 1 0C for 120 days. The samples were analyzed periodically for color, total soluble solids, pH and titrable acidity.

Ginger is used throughout the world as a spice or fresh herb in cooking and a variety of other value-added products including flavoring in candies, beverages, liqueurs, ice cream, baked goods, curry powder blends, sauces, and various condiments. Ginger is also used in traditional medicine to treat several ailments including nausea, motion sickness, migraine, dyspepsia, and to reduce flatulence and colic. Young rhizomes that are harvested early are also used in pickles and confectionery. One hundred grams of edible ginger contain approximately 9 g protein, 6 g fiber, 116 g calcium, 71 g carbohydrate, and 147 IU of Vitamin A (Farrell, 1999).

Drying is a critical step in the processing of dehydrated products because of the high energy requirement of the process (due to low thermal efficiency of dryers. Increased consumer awareness of food quality as well as the desire to produce a high quality has emphasized the necessity of optimization. Dryer design, simulation and optimization are complex processes still based on experimental data (Fellows, 1998). The use of artificial drying to preserve agricultural commodities is expanding, creating a need for more rapid drying techniques and methods that reduce the large amount of energy required in drying processes. New and innovative techniques that increase drying rates and enhance dried garlic quality are receiving considerable attention (Mongpraneet, 2002). Drying is dependent on the two fundamental process-Heats and Mass transfer, heat has to be transferred into the fresh products which are then followed by the removal of moisture from the products (Keey, 1980).

Sharma and Prasad (2001) studied the color change of fresh garlic in a hot air dryer at 70 0C and rather large number of mercaptans, disulfides, trisulfides and thiophenes (Li and Shi Ving, 2007) reported 90.2 percent retention of thiosulphates with microwave-vacuum and freeze drying. More than 50% of the water is taken out with the help of hypertonic solutions. After that, the fruit pieces are very soft and are still subjected to spoilage by a variety of microorganisms. The water content needs to be lowered further to gain microbiological stability without cool storage. Osmotic dehydration (OD) and pretreatment prior to drying was found advantageous for improving the product quality and for decreasing energy consumption (Mandala et al., 2005 and Lawson et al., 1995).

Recent efforts to improve on sun drying have led to solar drying. Solar drying also uses the sun as the heat source. A foil surface inside the dehydrator helps to increase the temperature. Ventilation speeds up the drying time. Shorter drying times reduce the risks of food spoilage or mold growth. It is a complex operation involving heat and mass transfer which may cause changes in product quality. Physical changes that may occur include shrinkage, puffing and crystallization. In some cases, desirable or undesirable chemical or biochemical reactions may occur leading to changes in color, texture, odor or other properties of the food product. Drying can either be an alternative to canning and freezing or complement these methods. Drying occurs by vaporization of the liquid by supplying heat to the wet feedstock. Heat may be supplied by conduction (contact or indirect dryers), by convection (direct dryers), by radiation or volumetrically by placing the wet material in a microwave or radio frequency electromagnetic field. Over 85% of industrial dryers are of convective type with hot air or direct combustion gases as the drying medium. Solar drying is often differentiated from “sun drying” by the use of equipment to collect the sun’s radiation in order to harness the radioactive energy for drying applications. Sun drying is a common farming and agricultural process in many countries, particularly where the outdoor temperature reaches 30°C or higher. In many parts of South East Asia, spice s and herbs are routinely dried. However, weather conditions often preclude the use of sun drying because of spoilage due to rehydration during unexpected rainy days. Furthermore, any direct exposure to the sun during high temperature days might cause case hardening, where a hard shell develops on the outside of the agricultural products, trapping moisture inside. Therefore, the employment of solar dryer taps on

the freely available sun energy while ensuring good product quality via judicious control of the radioactive heat. Solar energy has been used throughout the world to dry products. Such is the diversity of solar dryers that commonly solar-dried products include grains, fruits, meat, vegetables and fish. A typical solar dryer improves upon the traditional open-air sun system in five important ways (Wang, 2002).

Kim et al. (1992) reported that soaking of garlic slices in 0.5% sodium metabisulphite solution for 20 min prior to drying at 55-85°C reduced pyruvate loss during heating, inhibited browning and reduced microbial counts compared with the un-sulphited control. Re-hydration rate was not affected by sulphite treatment and the sulphited garlic dried at low temperature had the highest sensory score.

Jebson and Youzhang (1994) developed a new procedure to produce high-quality dried garlic powder in which most of the characteristic flavors are preserved. A two-part drying technique was tested, in which garlic samples were dried either as large pieces at high temperature, or as thin slices and at lower temperature in order to preserve the enzyme allinase. It was demonstrated by sensory panel trials that the new garlic powder was preferred to a commercially available garlic powder. Effects of sample size, air temperature, humidity, and flow rate on drying rate were studied in an air tunnel drier. At smaller sample sizes, the drying rate increased significantly. Higher air temperature and increasing air flow rates also significantly improved drying rates, but the effect of air humidity was more complex. Changing the drying air humidity did not have much direct effect on drying rates but had a negative effect (i.e. decreased the drying rates) if the drying temperature was high.

Application of response surface methodology (RSM) to drying of garlic, for production of high quality flakes, was examined by Madamba (1997). Garlic was air dried in a forcedair pilot plant under various conditions of relative humidity, temperature, air flow rate, slice thickness, loading density and initial moisture content, in a 27-run Box and Behnken design. Independent variables used in optimization were temperature, slice thickness, air speed and relative humidity. Quality factors evaluated were color (CI E L value and/or optical index), final moisture content and re-hydration ratio. Second order polynomial models for color parameters were significant, while the re-hydration ratio and final moisture content were not. By superimposing the contour plots, an optimum drying temperature of 70°C was

obtained, for 2 mm thick garlic slices, with predicted values close to experimental values.

Ambrose and Sreenarayanan (1998) conducted studies to standardise the conditions for production of garlic powder and to evaluate its storage stability and other quality attributes. Fresh garlic cloves (*Allium sativum L.)* were dehydrated by 4 methods: sun drying; solar cabinet drying; mechanical drying; and fluidized bed drying. The dried material was powdered and evaluated for drying characteristics and sensory qualities. Drying at 60°C for 4 h in a fluidized bed drier gave good qualitypowder with moisture content below 3%. Shelf life of the powder after three months of storage under ambient conditions was found to be better when aluminium laminate or brown glass bottles were used as packaging. The product prepared from garlic powder was highly acceptable as determined by sensory evaluation.

Hong et al. (1999) studied the effects of processing treatments (chopping, boiling and microwave treatment) on the composition and change of flavor compounds in garlic cloves (*Allium sativum L.*) and garlic extracts. 17 major flavor compounds were found in intact garlic cloves. The production and loss of volatiles was high when garlic was chopped. Microwave treatment was more effective in preventing the loss of non-protein sulphur compounds. The results suggest that microwave processing garlic is an effective method for preserving its functional compounds.

Sharma and Prasad (2001) examined the possibility of using combined microwave-convective drying for garlic cloves. 100 g garlic clove samples were dried in an experimental microwave-hot air drier at temperature of 40-70ºC; air velocity was 1 or 2 m/s and microwave power was 40W. Hot air drying experiments (60 and 70°C; 2 m/s air velocity) were also conducted for comparative purposes. The drying methods were compared with respect to drying time and sensory quality of dried products. Combined microwave-hot air-drying process reduced drying time by 80-90% and resulted in dried garlic products, which had higher scores for sensory quality as compared to hot air drying. The empirical form of Page's model described the combined microwave-hot air-drying process adequately.

Kajitani (1973) produced stabilized onion and garlic powder by mixing comminuted onion and garlic extracts with an aqueous extract of amylo-dextrin and drying to yield a powder having little onion or garlic odor until dissolved in hot water. Yamada

(1973) patented the process of preparing garlic powder free of alliin decomposition. The method involves steeping ground garlic, lactose and potato starch in an aqueous solution of vinegar or acetic acid and sodium chloride. Registered the method for the manufacture of stabilized garlic powder for use as a seasoning and food. According to this method whole garlic cloves were deep-frozen, preferably to 30°C, using solid CO_2, and finely ground in the deep-frozen state. The resultant powder was freeze-dried, and finely ground. It was claimed that the enzymatic decomposition of the active substance alliin was prevented. Powell (1973) patented seasoning compositions based on mixtures of garlic powder and paprika, which may be blended with other seasoning ingredients such as onion powder, salt and black pepper.

Goyal and Mathew (1990) reported the effect of three methods of drying (open sun drying, shade drying and by means of a solar drier) on cauliflower, with or without blanching, on the quality of the dried product. All dried samples were analyzed for proximate composition, ascorbic acid, water-soluble sugar, tryptophan, iron, phosphorus, sodium, potassium, and calcium. Result showed that blanching followed by solar drying produced the shortest drying time, best organoleptic properties and the lowest nutrient losses.

Verma and Gupta (1996) conducted a study on aonla (Banarsi) drying in the open sun various pre-drying treatments (slicing or a combination of pricking + blanching + sulphiting (soaking in 0.1% KMS for 5 min). Ascorbic acid retention after drying was highest (64%) in sliced samples and lowest in untreated samples. Rehydration parameter also best in the slicing treatment. All the treatments significantly improved color and overall acceptability compared with untreated samples but pricking did not improve texture, Taste and appearance.

Avila (1997) reported that dried garlic bulbs in natural conditions is a very practical and economical in dry and warm regions, but losses are significant whereas artificial drying is rapid, safe and more effective. The stages of the drying process and the factors affecting its rate are reviewed. The combined use of organoleptic and biochemical characteristics are considered for assessment of progress during drying under different conditions of management and climate.

Avila (1998) studied about the curing and drying of garlic bulbs. These are ambiguous terms, which need standardized parameters in order to define the "optimal point" for

the end of the process. Weight loss, organoleptic characters and contents of soluble essential oils or solids, essential oil or pyruvate, are common variables used to evaluate the ongoing process.

Mangaraj et al. (2001) reported that the drying time was minimum for mechanical drying, followed by solar cabinet drying, green house type solar drying and open sun drying. The overall quality was found to be better in mechanical drying followed by green house type solar drying and open sun drying. The green house solar drying was most economical, followed by solar cabinet drying, mechanical drying and open sun drying.

Sharma and Prasad (2001) conducted an experiment on drying of garlic cloves with hot air and combined microwave-hot air drying methods in an experimental dryer. The combined microwave-hot air drying experiments were carried out with 100 g sample sizes at temperatures of 40ºC, 50ºC, 60ºC and 70ºC at air velocities of 1.0 and 2.0 m/s, using continuous microwave power of 40 W. For comparison of hot air drying, the same sample sizes were taken for experiments and the drying air temperatures and air velocity were 60ºC and 70ºC, and 2.0 m/s respectively. The total drying time, the color and flavor strength of dried garlic cloves were used to evaluate the performance of the combined microwave-hot air-drying and the conventional hot air drying processes. Combined microwave-hot air-drying resulted in a reduction in the drying time to an extent of 80-90% in comparison to conventional hot air drying and a superior quality final product.

Jain and Tiwari et al. (2003) reported that open sun drying (OSD) was the most common method of crop drying in developing countries. Despite several disadvantages, it is widely practices because it is a simple way of drying. Crop temperature, temperature around the crop, solar temperature, and rate of moisture evaporation are the important parameters in OSD. The terminal behavior of OSD of garlic was also studied.

Roby et al. (1999) reported the drying of garlic in Mendoza, Argentina, either traditionally in bundles on racks in the field or in solar-power or electric drivers. After drying, garlic was stored in a refrigerator at 0°C or 18-22°C in a storehouse. Weight loss did not differ significantly between drying methods because of low atmospheric RH.

Possible health effects of garlic (*Allium sativum*) are discussed with reference to traditional health benefits of garlic, active ingredients, and possible links of garlic with health of the Mediterranean diet, possible hypocholeaterolaemic action of garlic, possible blood pressure lowering action and the small number os high quality studies on health effects of garlic (Beaglehole,1997).

Hong-Gyung Hoon et al (1997) reported a new HPLC technique to quantity allin in garlic(garlic powder from Korea Republic) using laboratory made allin as a standard. The synthetic allin was identified as a component of garlic by qualitative analysis through HPLC. The synthetic allin was purified as white, needle-shaped crystals. The retention time of the peak in HPLC analysis of synthetic allin was about 18 minute. This was similar to that observed on the garlic sample.

Waris-Qidwai et al. (2000) developed in order to estimate the dietary intake of garlic per person per month and to record three blood pressures reading on each individual. The various demographic parameters including age, sex, marital status and educational were recorded. Those subjects found to be over weight, with a known history of hypertension, diabetes mellitus, heart disease, and smoking and on medications which affect blood pressure, were excluded from the study to remove the effect of confounding variables on blood pressure, the data were analyzed. An average garlic use of 134g per month was found; 67% of the subjects used garlic in cooked food while the rest used it either in the raw form; 59% through that the dietary use of garlic is healthy. Subjects with blood pressure on the low side were found to consume more garlic in their diets (statistically significant for systolic blood pressure only).

Jia-kiv et al. (1996) investigated those volatile compounds in garlic GC-MS. The GC profile of volatile components in pickled garlic was similar to that of unpickled samples. Quantities of volatile compounds increased in unpickled samples process for microencapsulation of oleoresing, extracted from fresh garlic using 55% ethanol isolation, has been described Xiang et al. (1997). Edible gum was used as the wall material and the process involved emulsification, homogenization and spray drying. Micro capsules had a moisture content of 7-12%, core material inclusion rate at 97%, recovery rate 89.5% and an active garlic essence of 0.48% (W/W); residual ethanol concentration was 4.2 ppm.

Jui-sen et al. (1996) studies effects of 0.15 KGY y irradiation on the content of volatile compounds in garlic bulbs during at room temperature. Content of diallyl disulphide decreased (by 28%) immediately after un-irriadiated samples shows a significant increase in diallyl disulphide.

Kubee et al. (1996)evaluated that thirty four garlic samples used as spice and/or health preparation were analyzed by HPLC-UV for the content of the major garlic component, allin and its 5 decomposition products 2-viny-[4H]-1, 3 dithin, 3-viny-[4H]-1, 2dithin, diallyl disulphide, allylmethyl disulphide and dially trisulphide. Data were subjected to principal components analysis. Samples were divided into 4 catagoies according to chemical composition, i.e. fresh garlic bulbs, dried garlic products (powders, granulates and tablets), macerates in vegetables oils (salted garlic pastes, soups and bouillons had very chemical composition) and garlic essential oils.

There are many studies which prove hypotensive effect of ginger when it was given at 0.3-3 mg/kg. It helps to reduce atrial blood pressure by blocking calcium channel or by acting on muscarinic receptor (Ernst and Pittler, 2004; Portoni et al., 2003; Ozgoli and Goli, 2009; Vutyavanich et al., 2001).

Malik et al., (1997) isolated vitamin E (α-tocopherol) from garlic. The method involved homogenization of garlic in phosphate buffered saline and extraction with heptane in the presence of lithium diallyl sulphate. An aliquot of the extract, when analyzed by HPLC on a C_{18} column, yielded a peak with the same retention time as α-tocopherol standard. A total of 9.4 μg of α-tocopherol was isolated from one gram of garlic. Oxidation of low density lipoprotein was retarded by garlic α-tocopherol. A inactivating the enzyme 'allinase'. It had almost the same composition as that of garlic powder except in respect of allicin, the pungent principle, which could be regenerated at will by ether incorporation of fresh enzyme or fresh crushed garlic in small quantity (Pruthi, 1998). Garlic salt is prepared by mixing rapidly garlic powder; 20parts; refined pulverized salt; 78 parts; and anti-caking agent (usually calcium stearate or equivalent): 2 parts. Accordingly, the composition will be in proportion to the garlic powder used. How, the major points of difference would be total ash; 82.32% water soluble ash; 78.43%, ash insoluble in acid; 1.04%. The higher ash and soluble ash values are due to the added 78% common salt and higher acid insoluble ash due to the added calcium stearate (anti-caking agent) (Pruthi, 1998).

Madamba et al., (1993) studied that the bulk density of garlic sliced at different moisture levels (ranging from approx 3 to 65% m.c. wet basis). The porosity was calculated using its relationship with bulk apparent densities. An analysis of variance (ANOVA) revealed that bulk density and porosity were affected significantly by moisture and slice thickness as well as the interaction of these variables. But density varied in a positive linear fashion with moisture and thickness while a negative linear correlation was found for the calculation bulk porosity. The linear model met the adequacy criterion for characterizing the behavior of garlic using a laboratory unit, the vertical resistance to flow through the product and the effect of moisture and slice thickness were investigated.

Sham-Ud- Din et al., (2001) conducted a feasibility study on the preparation of Chili paste and observed the effects of preservatives ((KMS) and sodium benzoate) on the keeping quality of Chili paste. The study showed that Chili paste packed in polyethylene bags with 750 ppm of KMS or sodium benzoate could be preserved for 21-28 days at room temperature. The Chili pastes without preservative got spoiled within 2-3 days. This investigation opens the further possibility of conducting detailed work involving Chili and other spice pastes, various packaging materials, other preservatives at different concentration and combinations, different storage temperatures, effects of different treatments on the composition of the products and aspects.

Isidoro et al., (1995) stated that the effect of pod maturity, cv., time of harvest and length of storage were studied with respect to color stability of red Chili powder. Color retention of Chili powder was studied using 2 mildly pungent long red Chili. Delaying harvest resulted in color loss of red Chili; color of powder from later harvests was more stable and better retained after 8 wk. storage then powder obtained from the 1st harvest after the same time.

Rangana and Bajaj (1966) reported that “preservatives” are “food additives” used to prevent infection or inhibit spoilage caused by bacteria, yeast, mold or other microorganisms. It may be organic or inorganic.

Ahmed et al., (2002) reported that processed garlic paste was prepared from fresh garlic so that a convenient, shelf stable product with fresh garlic Odor could be manufactured. The prepared paste contained 10% sodium chloride with a pH value of

4.1. The product was thermally processed at selected temperature (60, 70, 80 and 90ºc) for a residence time of 15 min and stored at 10+2ºc. The effects of thermal treatment and storage of the product on the Hunter color values (Lightness index, L; greenness and redness, a; and yellowness and blueness, b) were studies. Among various color combination, -La/b described well the variation of total color with process temperature and storage period.

Furia (1972) stated that SO_2 and sulphites in the Body are oxidized to harmless sulphate and excreated out through urine. It destroys thiamine and usually is not used in food, which is good source of thiamin.

Rangana and Bajaj (1966) also reported that SO_2 (inorganic agent) is widely used throughout the world principally in treating food of plant origin. It is used in the prevention of fruits juices, pulps, beverages and concentrations. Concentration used may very from 350 to 2,000 ppm, soluble sulphite salts (e.g. KMS) are usually used in treating fruits and vegetables products. The acidity is higher at pH below 4.0.

Furia (1972) stated that sulphiting is done to inhibit microbial as well as enzymatic and non-enzymatic discoloration of some foods. The use level of sulphites is limited by the fact that, at residual levels above 500ppm, the Taste beings to be noticeable. Ingested quantities are usually less than those initially added to foods because of loss by evaporation in storage and from cooking. SO2 and sulphites in the body are oxidized to harmless sulphate and excreted in the urine. It destroys thiamine and usually is not applied in food which is good sources of thiamine.

FSIS (2002) conducted a survey to investigate 3 categories of food sold in UK, which are suspected to be irradiated but not Labeled as such. Food samples were purchased over August and September 2001, from 5 locations and from Internal suppliers and mail catalogues. A total of 543 samples were analysed : 203 herb and spice samples (basil, dill, oregano, parsley, rosemary and thyme; aniseed, black pepper and cayenne pepper, cinnamon, Chili powder, cloves, coriander, cumin, curry paste and power, ginger, Garamond masala, mixed spice, nutmeg, paprika, turmeric, and white pepper), 138 dietary supplement samples (alfalfa, aloe Vera, cat's claw, devil's claw, garlic, ginger, Gingko balboa, ginseng, green tea, guarana, kava, saw Palmerston, submarine and turmeric), and 202 prawn and shrimp samples. Methods such as photostimulated luminescence and thermoluminescence were used. Of all the samples

analyzed, one of the herbs and spices, 5 prawns and shrimps, and 58 dietary supplements were identified as having been irradiated or containing irradiated components.

Jost (1997) found that in a 5- weeks trial with 128 large white piglets,diets containing 0.05 or 0.25% garlic powder were compared with a negative control and a positive control supplemented with Mecadox 50mg/kg. when 0.05% garlic was given, a daily weight gain 444 g and a feed conversion ratio of 1.777 were observed compared with 382 g and 1.883 in the negative control group. Addition of Mecadox improved daily weight gain,465 g,0.25% garlic powder resulted in a daily weight gain which was identical to that in the negative control group (376 and 382 g,respectively).

Gara et al.(2000) designed to assess the in vivo anti-H. Pylori potential of a verity of garlic substances. The garlic materials all showed substantial but widely differing anti-H. Pylori effects against all strains and isolates tested. The MICs (range,8 to 32 mg/ml) of undiluted garlic oil (GO) were smaller than those of garlic powder (GP) (MIC range, 250 to 500 mg/ml; MBC range, 250 to mg/ml;) but greater than the MIC of allicin (4.0 mg/ml); present in GP. Allicin (MIC, 6mg/ml; MBC, 6 mg/ml); was more potent than diallyI disulfide (MIC range, 100 to 200 mg/ml; ABC range, 100 to 200 mg/ml); its corresponding sulfide, but of a strength similar to that of diallyI tetrasulfide (MIC range, 3 to 6 mg/ml); Anti-microbial activity of the diallyI sulfide increased with the number of sulfur atoms. Time course viability studies and microscopy showed does-dependent anti-H. Pylori effects with undiluted GO, GP, and diallyI trisulfide after a lag phase of Ca. 1 to 2 h. Substantial in vitro anti-H. Pylori effects of pure GO and GP and their diallyI sulfur components exist, suggesting their potential for in vivo clinical use against H. Pylori infections.

Alam (2003) conducted a feasibility study on the preparation of turmeric paste and observed the effects of preservatives (KMS and sodium benzoate) on the keeping quality of turmeric paste. The study showed that turmeric paste treated with 0.5% or 1% citric acid plus 1000 ppm of sodium benzoate of mixed preservatives, when stored in polyethylene bag or plastic bottle at room temperature, were acceptable up to 120 days of storage. The refrigerated storage with 1000 ppm sodium benzoate plus 1% citric acid in both polyethylene bag and plastic bottles. Thus turmeric paste was found more stable in both room and refrigerated storage using 1% citric acid plus 1000 ppm

sodium benzoate. The study showed that turmeric paste without any preservatives could be kept up to 9 days only in polyethylene bag and 15 days in plastic bottle at room temperature.

Mishra (1972), reported that artifical drying or mechanical drying Chilies dried at 60°C turned black and lost part of their pungency and glossiness, and recommended a range of temperatures, 45-50°C as suitable.

Garg and Krishna (1974), reported that by the use of solar drier the drying time for Chilies can be reduced to nearly half of the open drying method. The quality of the Chilies dried by solar drier was also superior.

Malviya and Gupta (1985), reported that when Chilies were dried by natural convection solar drier, solar cabinet drier, dehydrator and open sun drying to compare the performance, no disColoration, charring or fungal growth were observed in the natural convection drier. However whilst dis-Coloration and charring occurred in the solar cabinet drier. Open air sun drying took longer time and the organoleptic quality of the dried product was also affected.

Joy et al. (2001), reported that the results of quality analyses of both tunnel dried Chili samples and those Chili samples dried by conventional methods, collected from the same sampling locations were compared. Considerable reduction in drying time was noticed in tunnel-dried samples.Improvement in overall quality parameters, cleanliness and texture were noticed in tunnel-dried Chili samples. Optimum conditions required for the drying of red Chili could be identified.

Mngraj et al. (2001), reported that the time taken for drying was minimum for mechanical drying, followed by solar cabinet drying, green house type solar drying and open sun drying. The overall quality was found to be better in mechanical drying followed by green house type solar drying and open sun drying. The green house solar drying was most economical, followed by solar cabinet drying, mechanical drying and open sun drying.

Srivastava et al. (1994) noted that fresh Chilies are perishable crops, has very short shelf-life due to their high moisture content 85.7%. To increase the shelf life of Chilies, it is necessity to be processed either into wet or dry products. Wet processed products usually are canned, frozen, pickled and chutneys. Dry processed products are

Chilies that are dehydrated after harvest and left as whole pod, processed into flakes or powder.

Dumulin and Lozada (1982) Achieved that primary processing of Chilies essentially consisted of drying and de-spiking. Better retention of color and higher yield of finished product, avoiding breakage of pods and loss of seeds are achieved by adopting improved technologies. The important quality factors considered for dry chilies are variety, color, size, shape, seed content, pungency, flavor, free from dirt, dust, foreign matter (both organic and inorganic), damage and moisture content.

Minquez et al. (1994) revealed that drying system with wood combustion provoked an increase in the concentration of some pigments which could be interpreted as reflecting synthesis. During fast drying there was no increase in the concentration of any pigment only the degrative losses were measurable. The importance of drying stage was evident since increase or decrease in concentration of pigments depend on temperature and time employed.

Mangaraj et al. (2001) evaluated the performance of different drying methods for Chilies viz., open drying, green house type solar drying, solar cabinet drying and mechanical drying. It was noticed that time taken for drying was minimum for mechanical drying, followed by solar cabinet drying, green house type solar drying and open sun drying. The overall quality was found to be better in mechanical drying followed by the green house type solar drying, solar cabinet drying and open sun drying. Joy et al. (2001) studied the solar tunnel drying of red Chilies and found that Chilies dried were hygienic and of high quality over commercially available sun dried Chilies with reduced drying time.

Chen and Mujumdar (2008) reported that Drying is one of the most cost and effective ways of preserving foods of all variety by applying the heat for removal of water. There are a variety of food products are pre-served using drying including meat products, marine products as well as all types of fruits and vegetables. Most of the food products contain 90% or more moisture which needs to reduced the water to an acceptable level to avoid deteriorate of the food quality.In addition, to that the varieties of food product needs to be dried by using different drying methods.

Mujumdar (2004) achieved that all variety of food products in our day to day life needs to increase the shelf life by using permitted preservatives. Toontom et al. (2010) presented the result that Chili is one of vegetable crop which is easily spoil .So that is mandatory to apply one of preservation methods to expend the shelf life of Chilies. Dried Chili is a spice product that is most widely used as condiments for Coloring and Flavoring in Asian cuisines.

Khatun (2012) achieved that the effects of drying methods, packaging materials and KMS (Potassium Meta-bisulphate) on the keeping quality of the green Chili powders during 15 up to 60 days storage period. Studied showed that the green Chili powder obtained by treatment with 500 ppm of KMS solution and mechanical drying process was most acceptable in respect of color, flavor, pungency and texture followed by sun dried green chili powder treated with 500 ppm of KMS.

Chapter 3: Materials and Methods

3.1 Site and period of study

The study was conducted in the laboratory of the Department of Food Processing and Engineering, Pharmacology and Biochemistry and Poultry Research and Training Center of Chittagong Veterinary and Animal Sciences University, Chittagong. The study was conducted for a period of six month from 1st June,2018 to 30th December ,2018.

3.2 Collection of sample

Ginger, Garlic and Green chili were collected from local market such as chowdhuryhat, oxygen area of Chittagong for the laboratory analysis.

3.3 Sample identification

Table 3.1 Samples and sample codes

Sample Name	Codes of samples		
	Ginger	**Garlic**	**Green chili**
Fresh	FGi	FGa	FGC
Sun dried powder	SuGi	SuGa	SuGC
Cabinet dried powder	CaGi	CaGa	CaGC
Shade dried powder	ShGi	ShGa	ShGC

Here,

Ginger powder,

FGi= Fresh ginger

SuGi = Sun dried ginger powder

CaGi = Cabinet dried ginger powder

ShGi = Shade dried ginger powder

Garlic powder,

FGa = Fresh Garlic

SuGa = Sun dried garlic powder

CaGa = Cabinet dried garlic powder

ShGa = Shade dried garlic powder

Green Chili Powder,

FGC = Fresh Green chili

SuGC = Sun dried green chili powder

CaGC = Cabinet dried green chili powder

ShGC = Shade dried green chili powder

3.4 Processing and preservation techniques

3.4.1 Preparation of powder and paste

3.4.1.1 Pre-treatment of samples

The skin of selected spices were washed gently with distilled water, then cleaned properly with cotton cloth to remove dust, adhered particles and agricultural chemicals then were stored in a cool and dry place.

3.4.1.2 Sun drying

A sample of 500 gm was dried in open sun by placing it over a tray. Sun drying for three days. After drying, they were allowed to cool naturally to ambient temperatures of 23-25ºc. Sun dried products was packaging with plastic bottle and was stored at room temperature prior to analysis.

3.4.1.3 Shade drying

It was similar to open sun drying except the samples were placed in shade. The samples were dried at the first floor of the college corridor. The drying was single thin layered.

3.4.1.4 Mechanical drying

Cabinet drying at 60ºc for 24 hrs and then cooling at room temperature. The dried products were grounded into powder in a blender separately. Then they were sieved and packaged in plastic containers. All plastic containers containing ginger powder were identified and stored at room temperature.

3.4.2 Preparation of paste

The sample was peeled, sliced and blended (20 minutes) in warring blender to prepare paste using 50 gm of water per kg of sample. The citric acid was added to bring down pH from 6.1 to 4.4. The prepared paste was then divided into desired number of lots and mixed with two types of preservatives such as potassium metabisulphite and sodium benzoate or in combination at the rate of 500, 750 and 1000ppm. These treated samples (50 gm each) were packed in plastic bottles for further study.

Table: The detailed treatments are shown in Tables: (all paste samples)

SI No	Treatments	Packaging Material	Storage Condition
1	Potassium metabisulphite (KMS) 500 ppm, 750 ppm or 1000ppm	Plastic bottle	Room temperature (30ºc)
			Refrigeration temperature (6ºc)
2	Sodium benzoate 500 ppm, 750 ppm or 1000ppm	Plastic bottle	Room temperature (30ºc)
			Refrigeration temperature (6ºc)
3	Mixed preservative (Sodium benzoate : KMS=50:50) 500ppm, 750ppm or 1000ppm	Plastic bottle	Room temperature (30ºc)
			Refrigeration temperature (6ºc)
4	Control (without preservative)	Plastic bottle	Room temperature (30ºc)
			Refrigeration temperature (6ºc)

(Source: AOAC, 2000)

The paste prepared from fresh peeled garlic was packed (28gm) in each, plastic bottle and stored at ambient temperature (30ºc) and refrigeration condition (6ºc) for 180 days. The observations were made at 15 days intervals for moisture contents, ash, pH, and vitamin C (ascorbic acid) contents as per the method of AOAC (2000). The color, flavor, texture and microbial qualities were also evaluated during storage of the paste. For comparison, a control sample of paste (without any preservatives) was also included in the study.

3.5 Physicochemical properties

The properties of TSS (Total Soluable Solids) are measured by hand refractometer, TA (Titrable Acidity) ARE measured by titrable value and pH are measured by pH meter.

3.5.1 Determination of Total Soluble Solids

Total soluble solid contents were recorded with the help of a hand refractometer. Crushed fruit pulp was placed on the prism of the refractometer and readings were observed through the eye piece. For accurate measurement the readings taken were corrected for temperature variations to 20°C and results expressed as °Brix (Ranganna, 1991).

3.5.2 Determination of titrable acidity

A known weight of the fruit sample was crushed and taken in a 100 ml volumetric flask and the volume was made up by adding distilled water. After filtration, 10 ml of the filtrate was taken in a separate conical flask and titrated against 0.1 N sodium hydroxide using phenolphthalein as an indicator. The end point was determined by the appearance of a faint pink Color. Titratable acidity was calculated (Ranganna, 1991).

Calculation: The titratable acidity was determined by using the following calculations

$$\text{Titratable Acidity (\%)} = \frac{T \times N \times V1 \times E}{V2 \times W \times 1000} \times 100$$

Where,

T = Titre value

N= Normality of NaOH

E= Equivalent weight of acid

V 2 = Volume of sample taken

V 1 = Volume made up

W= Weight of sample

3.5.3Determination of pH

The pH of fresh sample as well as dried and paste sample was taken with pH meter (Model- HI 98107; Company-Hanna instruments Italy). Prior to pH measurement, the instrument was calibrated with buffer solution of 4.0, 7.0 and 9.0. The pH of the samples was estimated directly (AOAC, 2004).

3.6 Proximate composition analysis

Moisture, protein, fat and ash contents of experimental groups were measured in triplicate according to AOAC methods. The moisture was measured by oven drying at

105°C to constant weight (AOAC, 2016).The crude protein content was measured by the kjeldahl procedure (6.25 x N). Total lipid was extracted by the AOAC (2016) method using the soxhlet system. Ash was measured gravimetrically in a furnace by heating at 550°C to constant weight (AOAC, 2016).

3.6.1 Moisture determination

At first weight of empty crucibles were dried for 1 hour at 100°C and 5 gm of sample was placed on it. Then the crucible was placed in an air oven (thermostatically controlled) and dried at room temperature of 100 to 105°C for 24 hours. After drying, the crucible was removed from the oven and cooled in dessicator. It was then weighted with cover glass. The crucible was again placed in the oven, dried for 30 minutes, took out of the dryer, cooled in dessicator and weighed. Drying, cooling and weighing were repeated until the two constant weight were same.

Calculation

From this weight the percentage of moisture in food samples was calculated as follows:

$$\% \text{ Moisture Content} = \frac{\text{Loss of weight}}{\text{Weight of sample}} \times 100$$

3.6.2 Protein determination

Reagents used

A. Concentrated sulphuric acid (nitrogen free)

B. Digestion mixture

i. Potassium sulphate = 100g

ii. Copper sulphate = 10g

iii. Selenium di-oxide = 2.5g

C. Boric acid solution = 2% solution in water

D. Alkali solution = 400g sodium hydroxide in water and dilute to 1 litre.

E. Mixed indicator solution = Bromocresol; 0.1g and Methyl red.: 2g dissolved in 250 ml ethyl alcohol

F. Standard HCL: 0.1 N

For estimation of protein, the steps were followed:

Digestion: 2g sample,3 g digestion mixture and 25 ml H2S04was taken in aKjeldahl digestion flask .It was heated for 4 hours in a Kjeldahl digestion and distillation apparatus. The digestion was completed when the color of the substance was pale yellow.

Distillation: After digestion 100 ml water ,100 ml 40% NaOH and glass blitzwere added to Kjeldahl flask which containing about 10ml 2% boric acid and 2-3 drops mixed indicator. About 100ml distillate was collected just before the distillation was stopped. The receiving flask was moved so that the tip of the distillating tube of the distillsate. Some distillate was collected in this way to make sure the condenser tube was free from traces of ammonia.

Titration: The ammonia collected was titrated with 0.1 N HCl solutions andtitre value was recorded.

Calculation

The calculation of the percent of protein in the sample using protein factor 6.25

$$\%\ \text{Nitrogen} = \frac{(\text{Ts} - \text{Tb}) \times \text{Normalityof HCl} \times 14 \times \text{Volume made up the digest} \times 100}{\text{Weight of sample(gm)} \times \text{Aliquot of the digest taken} \times 100}$$

Where,

Ts = Titre volume of the sample (ml)

Tb = Titre volume of the blank (ml)

% Protein = Nitrogen × Protein factor

3.6.3 Fat Determination

The dried sample was transferred to a thimble and plugged the top of the thimble with a wood of fat free cotton. The thimble was dropped into the fat extraction tube attached to a Soxhlet apparatus. Approximately 75ml or more of anhydrous petroleum

ether was poured through the sample in the tube into the flask. Top of the fat extraction tube was attached to the condenser.The sample was extracted for 16 hours or longer on a water bath at 70-80 $^{\circ}$C. At the end of the extraction period, the thimble from the apparatus was removed and distilled of the petroleum ether by allowing it or collected in Soxhlet tube. The petroleum ether by allowing it or collected in Soxhlet tube. The petroleum ether was poured off when its volume, was nearly full. When the petroleum ether had reached small volume, was nearly full. When the petroleum ether had reached small, it was purer into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask was rinsed and filtered thoroughly using petroleum ether. The petroleum ether was evaporated on steam bath at low temperature and was then dried at 100°C for 1hour, cooled and weighed. The deference in the weight gave the ether soluble materials present in the sample.

Calculation

The percent of crude fat was expressed as follows:

$$\%\text{Crude fat} = \frac{\text{Weight of petroleum ether soluble material}}{\text{Weight of sample taken}} \times 100$$

3.6.4 Ash Determination

The oven dried sample was taken in a muffle furnace at 600°C for 4 hours after charging over an electric heater. The difference between oven dried matter and final weight represented the ash, which was expressed in percentage.

Calculation

It was calculated using the following formula

$$\%\text{Ash} = \frac{\text{Weight of ash}}{\text{Initial weight of dry matter}} \times 100$$

3.6.5 Crude Fiber Determination

Reagents required

A. 0.255N sulphuric acid solution (i.e. 1.25g H_2SO_4/100ml water);

B. 10.0% Potassium sulphate solution;

Procedure

A 2 g sample was taken and transferred to the digestion flask with approximately 0.5 g asbestos. 200 ml of boiling sulphuric acid solution was added and immediately was connected the digestion flask with leibig condenser and was boiled briskly for 30 min. During digestion care was taken to keep material remaining on the sides of the digestion flask without contact with solution. After completed the boiling, the flask was removed and filtrated through line in a fluted funnel and washed with boiling water until the washing are no longer acid. Sodium hydroxide solution was heated to boiling under reflux condenser and washed the residue from acid digestion back into the flask with 200 ml of boiling sodium hydroxide solution and connected the flask with reflux condenser and boiled for exactly 30 min. After 30 min of boiling, the flask was removed and immediately filtered through filtering cloth in a fluted funnel washed with water and potassium sulphate solution. The residue was returned to the digestion flask thoroughly washing all residues from cloth will water. Then it was filtered into die Gooch crucible was prepared with thin but a packed layer of ignited asbestos. After washing of the residue in the Gooch crucible with boiling water, washing was repeated with approximately 15ml of alcohol. The crucible with the contents was dried at 110 C to constant weight and then cooled in a desiccators and weighed. The contents were ignited of the crucible in an electric muffle furnace at dull red heat (550 C) until carbonaceous is destroyed (approximately 20 min). Then it was cooled in desiccators and again weighed.

Calculation

The loss in weight represents crude fiber

$$\%\ \text{Crude fiber} = \frac{\text{Loss in weight noted}}{\text{Weight of sample taken}} \times 100$$

3.6.6 Determination of total carbohydrate

The carbohydrate content was determined by calculating the difference of Nitrogen Free Extractive (NFE). It was given as the difference between 100 and a sum total of the other proximate components. Hence it was calculated using the formula below:

% CHO = 100% - % (Protein + Fat + Fibre + Ash + Moisture content)

3.7 Determination of Vitamins

3.7.1 Analysis of vitamin C

Vitamin C were analyzed by UV spectro-photometric method, as described by Rahman et al. (2007). A Shimadzu spectrophotometer with a pair of 1 cm quartz cells was used.

Chemicals and reagents required

A. Standard vitamin C (ascorbic acid) solution
B. 5% Metaphosphoric acid-10% acetic acid: 15g of solid metaphosphoric acid (E. Merck) were dissolved in a mixture of 40 ml of glacial acetic acid (BDH) and 450 ml of dis- tilled water in a 500 ml volumetric flask. The solution was filtered and collected.
C. 110% Thiourea solution,
D. 2,4-Dinitrophenyl- hydrazine solution,
E. 85% Sulphuric acid

Preparation of standard vitamin C (Ascorbic acid) solution

Stock standard solution containing 0.5 mg/ml of ascorbic acid was prepared in water by dissolving 0.05 g of AA in 100 ml of water and stored in a glass stoppered bottle. Solutions of variable concentrations were prepared by diluting the stock solution in water.

Sample preparation

10 g blended sample was homogenized with about 50 ml of 5% metaphosphoric acid-10% acetic acid solution. Then it was quantitatively transferred into a 100 ml volumetric flask and was shaken gently until a homogeneous dispersion was obtained. Then it was diluted up to the mark by the 5% metaphosphoric acid-10% acetic acid solution. Then the solution was filtered and the clear filtrate was collected for the determination of vitamin C in that sample.

Estimation of vitamin C procedure

Bromine water was added to the filtered sample solution to oxidize the ascorbic acid to dehydroascorbic acid. Then a few drops of thiourea was added to it to remove the excess bromine and thus the clear solution was obtained.

Standard solutions of ascorbic acid (5 ppm,10 ppm, 15 ppm, 20 ppm and 25 ppm) were prepared from 500-ppm stock solution of ascorbic acid by proper dilution. Then 1 ml of 2,4- DNPH solution was added thoroughly with all standards and also with the oxidized ascorbic acid. For completion of the reaction, all the standards, samples and blank solution were kept at 37°C temperature for 3 hours in a water bath (thermostatic). After this incubation all of those were cooled in an ice bath and treated with 5 ml of 85% H_2SO_4 with constant stirring. As a result, a colored solution was obtained whose absorbance was taken at 521 nm.

Reactions

a. Ascorbic acid is oxidized to dehydroascorbic acid by the action of bromine solution.

b. L-dehydroascorbic acid reacts with 2,4- dinitrophenylhydrazine and produces an osazone which on treatment with 85% H2SO4 forms red colored solution.

Calibration curve

A calibration curve is used to determine the unknown concentration of an element. The instrument is calibrated using several solutions of known concentrations. A calibration curve is constructed by plotting the concentration versus the corresponding absorbance which shows the concentration against the amount of radiation absorbed. A calibration curve was plotted for standard vitamin C which was shown in appendix E.

3.7.2 Analysis of β-carotene

β-carotene were analyzed by UV-spectrophotometric method, UV absorption was performed in a range of 200-800 nm on a Shimadzu UV-Vis spectrophotometer ,as described by Karnjanawipagul et al. (2010). Then sample solutions were centrifuged.

Chemicals required

A. Tetrahydrofuran (THF)
B. Dichloromethane (DCM)
C. Sodium chloride (NaCl)
D. Anhydrous sodium carbonate (anhydrous Na_2CO_3)
E. All - trans β-carotene
F. Deionized (DI) water.

Standard and sample preparation

Standard β-carotene for identification was prepared in DCM to obtain 4 μg/mL. β-carotene in samples was extracted by the following procedure. Briefly, samples were washed with deionized water and cut into small pieces. Eighty grams of samples was blended with 8 g anhydrous sodium carbonate and mixed with a mechanical blender. Ten grams of the mixture was transferred into a centrifuge tube, added with 20 mL THF and mixed for 2 min under cold water. The mixture was centrifuge at 5000 g for 5 min and the supernatant was collected. Extraction was performed by adding 15 mL DCM and 15 mL of 10% w/v NaCl into the supernatant and shaken for 2 min. The extraction was repeated twice; organic layer was collected and evaporated under nitrogen steam. The residue was kept at -20ºC reconstituted with 5 mL DCM and diluted (1/40-fold) with DCM prior UV measurements.

Calibration curve

A calibration curve is used to determine the unknown concentration of an element. The instrument is calibrated using several solutions of known concentrations. A calibration curve is constructed by plotting the concentration versus the corresponding absorbance which shows the concentration against the amount of radiation absorbed.calibration curve was plotted for standard β-carotene which was shown in appendix E.

3.8 Analysis of minerals

The contents of Na, K, Ca and Mg were measured by Biochemical Analyzer, (Humalyzer 3000) commercially available biochemical kit (Randox®) was used for biochemical assay.

Sample preparation

10g of sample was taken and meshed up in a mortar with pestle adding 50ml of distilled water. Then it was filtered through muslin cloth and further filtered by whatman paper. Finally it was filled upto 100ml by distilled water.

3.8.1 Determination of sodium (Na)

Test principle: Sodium reacts with a chromogen producing a chromophore, theintensity of which is directly proportional to the concentration of sodium in the sample.

Reagent composition

REAGENT	COMPONENT	CONCENTRATION
R1 Sodium reagent	Chromogen	>100mmol/L
Sodium standard	Aqueous Sodium standard	150 mmol/L

Assay:

Wavelength / filter	630 nm (620-650 nm) /Green
Temperature	Room Temperature.
Light path	1 cm.

Pipetting Scheme

Pipetted into clean dry test tubes labeled as Standard (S) and Test (T):

Addition Sequence	Standard(ml)	Sample (ml)
Sodium Reagent	1.0	1.0
Deionized Water	-	-
Sodium Standard (S)	0.02	-
Sample	-	0.02

Mixed well and incubated at R.T. for 2 minutes. The absorbance of the standard (Abs.S) and Test Sample (Abs.T) was measured against Blank, within 60 minutes.

Calculation

Sodium (mmol/L) = (A)Sample/(A)Standard×Standard conc.(mg/dl)

3.8.2 Determination of potassium (K)

Test Principle

Sodium tetraphenylboron reacts with potassium in the sample to produce a fine turbidity of potassium tetraphenylboron. The intensity of turbidity is directly proportional to the concentration of potassium in the sample.

Reagent composition

REAGENT	COMPONENT	CONCENTRATION
Potassium TPB reagent	Sodium tetraphenylboron	0.2 mol/L
	Sodium hydroxide	2.2 mol/L
	Preservative	0.1`%
Potassium standard	Potassium	5 mmol/L

Assay

Wavelength / filter	630 nm (620-650 nm) /Green
Temperature	Room Temperature
Light path	1 cm

Pipetting Scheme

Pipetted into clean dry test tubes labeled as Blank (B), Standard (S) and Test (T):

Addition Sequence	Blank (ml)	Standard(ml)	Sample (ml)
Potassium Reagent	1.0	1.0	1.0
Deionized Water	0.02	-	-
Potassium	-	0.02	-
Standard(S)			
Sample	-	-	0.02

Mixed well and incubated at R.T. for 2 minutes. The absorbance of the standard (Abs.S) and Test Sample (Abs.T) was measured against Blank, within 60 minutes.

Calculations:

$$\text{Potassium}\left(\frac{\text{mg}}{\text{dl}}\right) = \frac{(B)Sample}{(B)Standard} \times \text{Standard conc.}\left(\frac{\text{mg}}{\text{dl}}\right)$$

3.8.3 Determination of calcium (Ca)

Reaction principle

Calcium ion forms a violet complex with O-Cresolphthalein complexion in an alkaline medium.

Reagent composition

REAGENT	COMPONENT	CONCENTRATION
Cal. Standard	Calcium	5 mmol/L
Buffer	2-amino-2-methyl –propan –l-ol	3.5 mol/l
Chromogen	O-Cresolphthalein complexone	0.16 mmol/l
	8-Hydroxyquinoline	6.89mmol/l
	Hydrochloric acid	60 mmol/l
EDTA		150mmol/l

Assay

Wavelength / filter	Hg 578 nm (550-590)
Pectrophotometer	570nm
Temperature	20-25°C / 37°C
Light path	1 cm

Pipetting Scheme

Pipetted into clean dry test tubes labeled as Blank (B), Standard (S) and Test (T):

Addition Sequence	Reagent Blank	Standard	Sample
Working Reagent (ml)	1.0	1.0	1.0
Deionized Water (µl)	25 µl	-	-
Standard (S) (µl)	-	25 µl	-
Sample (µl	-	-	25 µl

Mixed well and incubated at R.T. for 2 minutes. The absorbance of the standard (Abs.S) and Test Sample (Abs.T) was measured against Blank, within 60 minutes.

Calculations

Calcium (mg/dl)=(C)Sample/((C)Standard×) Standard conc.(mg/dl)

3.8.4 Determination of magnesium (Mg)

Principles

The method is based on the specific binding of calmagite,a metallochrome indicator and magnesium at alkaline pH with the resulting shift in the absorption wavelength of the complex. The intensity of the chromophore formed is proportional to the concentration of magnesium in the sample.

Calmagite+Magnesium ⟶ Calmagite magnesium complex

Assay

Wavelength	520 nm, Hg 546 nm 500-550 nm (Increase of absorbance)
	628 nm, Hg 623 nm, 570-650 nm (Decrease of absorbance)
Cuvette	1 cm light path
Temperature	20-25°C / 37°C
Measurement	Against reagent blank

Pipetting Scheme

Addition sequence	Blank	Sample or Standard
Sample or Standard	-	10 µ
Dist. Water	10 µl	-
Reagent	1000 µl	1000 µ

Mixed and absorbance was taken against blank after 5-60 min. at 20-25°C / 37°C.

Calculation

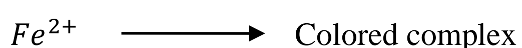
$$\text{Magnesium}\ \left(\frac{\text{mg}}{\text{dl}}\right) = \frac{\text{(D)Sample}}{\text{(D)Standard}} \times \text{Standard conc.}\ (\frac{\text{mg}}{\text{dl}})$$

3.8.5 Determination of iron (Fe)

Reaction principle

The iron is dissociated from transferring iron complex in weakly acid medium. Liberated iron is reduced into the bivalent form by means of ascorbic acid. Ferrous ions give with Ferro Zine a Colored complex.

Transferrin (Fe^{3+})2+e ⟶ $2Fe^{3+}$+Transferrin



Fe^{2+} ⟶ Colored complex

Reagent composition

REAGENT	COMPONENT	CONCENTRATION
Buffer	Acetate pH 4.9	100 mmol/L
Reductant	Ascorbic acid	99.7%
Color	Ferrozine	40 mmol/L
Iron cal.	Iron aqueous primary standard	100 µg/dl

Assay:

Wavelength	562nm (530-590)
Cuvette	1 cm light path
Temperature	37ºc/15-25ºc

Pipetting Scheme

Pipetted into clean dry test tubes labeled as Blank (B), Standard (S) and Test (T):

Addition Sequence	Reagent Blank	Standard	Sample Blank	Sample
WR(ml)	1.0	1.0	1.0	1.0
Ferrozine	1	1	-	1
Distilled water(µl)	200	-	-	-
Standard (µl)	-	200	-	-
Sample (µl)	-	-	200	200

Mixed well and incubated at R.T. for 2 minutes. The absorbance of the standard (Abs.S) and Test Sample (Abs.T) was measured against Blank. The Color is stable for at least 30 minutes.

Calculations:

$$Iron\ (\mu g\ /dl) = \frac{(E)Sample - (E)Sample\ Blank}{(E)Standard} \times 100\ (Standard\ conc.)\mu g/dl$$

Conversion factor:µg /dl×0.179=µmol/l

3.9 Microbial analysis

3.9.1 Enumeration of Total Plate Count (TPC) of Spices

The working principle of TPC analysis is the calculation of the number of bacterial colonies present in the sample with dilution as needed and done duplo. All work is done aseptically to prevent undesirable contamination and duplicate observation can improve accuracy. The number of bacterial colonies that can be calculated is a petri dish that has a bacterial colony between 30-300 colonies. Petri dishes, test tubes and pipettes before use are sterilized in oven at 180oC for 2 hours. The media was sterilized in an autoclave at a temperature of 121oC for 15 minutes at a pressure of 1 atm. After sterilization, to keep the media from freezing the media temperature is maintained at 45-55°C in a water bath. The diluents solution was prepared by dissolving 8.5 grams of NaCl in 1 liter of aqueduct which was then sterilized in an autoclave at 121 ° C for 15 minutes. The sample of 10 grams was mashed first, then dissolved into a sterile diluents solution that has been contained with a volume reaching 100 ml to obtain dilution 10-1. The solution is then pelleted 1 ml, then fed into a test tube containing 9 ml of a sterile diluents solution to obtain 10-2 dilution. And so on until obtained dilution 10-5. From each tube the dilution reaction is taken by using a pipette of 1 ml then put into a sterilized Petri dish. Each dilution is done in duplicate. Then each cup is moved in a circle on the table so that the PCA media evenly. After PCA freezes, the Petri dish is incubated in the incubator for 48 hours at 30°C; the Petri dish is placed upside down in the incubation.

3.9.2 Enumeration of Total Coliforms of Spices

Most Probable Number (MPN) method is used for the quantitative estimation for coliform (Feng et al., 2002). Serial dilution of the samples was prepared as described earlier. Nine test tubes of lauryl sulfate triptose broth (LSTB) with Durham's tube were taken to determine total coliform which grouped into 3 divisions. Tubes were taken for first 3 dilution i.e. dilution no 10^{-1}, 10^{-2}, 10^{-3}., but not for10^{-4}, and 10^{-5}dilution. First 1 ml of sample was inoculated from 10^{-1} dilution by sterile pipette to first test tube of first group. Again 1 ml of sample was inoculated from10^{-1} dilution by sterile pipette to second test tube and lastly it was again repeated for 3 test tubes of first group. By this way rest of the 6 test tubes from 10^{-2} and dilution 10^{-3} dilution were inoculated. All nine tubes were incubated at 37ºc for 48 hours. After incubation, gas producing tubes were marked and recorded. After that, total coliforms

were counted from the most probable number (MPN) chart from USFDA, Bacteriological analytical manual 6th edition 1984.

3.10 Sensory Evaluation of Powder and Paste

A panel of 10 judges was selected based up on the hedonic scale for sensory evaluation (Tummala et al., 2008). The judges were suitably trained to get acquainted with the attributes of green chili powders. The powder was evaluated for their sensory attributes like- color, flavor, pungency and overall acceptability by the panel of judges using 9 point hedonic scale. The panel of judges were evaluated the samples at different intervals. The scores were recorded over a hedonic scale with a maximum score of 9 for “like extremely” and minimum of 1 for “dislike extremely”.

3.11 Statistical analysis

Data collected in this study was analyzed using MS Excel, 2007 and SPSS (Statistical Package for the Social Sciences) version 16.0 was used to compare differences in the means of the moisture, ash, protein, carbohydrate, crude fiber, fat, TSS, titratable acidity, vitamin C ,β-carotene. A significant difference was considered at the level of $p<0.05$.

Chapter 4: Results

Fresh spices such as ginger, garlic and green Chili are generally rich source of vitamins, minerals, antimicrobial agents and phytochemicals, as well as dilatory fiber and poly phenols. Different processing and preservation process such as different drying process and storage condition have negative effects on nutritional composition of spices. The data recorded on ginger, garlic and green Chili durithe course of investigation have been presented in this chapter along with appropriate table, figures and illustrations.

4.1 Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of ginger powder and paste

4.1.1 Ginger Powder

4.1.1.1 Changes in physicochemical parameter of ginger powder

Physicochemical parameter of fresh ginger were TSS are 5±0.57ºB, pH are 6.16±0.15 and acidity are 2.03±0.06. The TSS, pH and acidity of sun dried, cabinet dried and shade dried contents of ginger powder were 6ºBrix to 5ºBrix, 65.1% to 4.86% and 1.21% to 1.29% respectively in different processing and preservation methods.

Table 4.1 Changes in physicochemical parameter of ginger powder[A,B]

Variable	Sample			
	FGi	**SuGi**	**CaGi**	**ShGi**
TSS(ºBrix)	5 ±0.57^{a}	6 ±0.94^{a}	5±0.57^{b}	5±0.58^{c}
pH(%)	6.16±0.15^{b}	65.1±0.10^{ca}	4.96±0.05^{ca}	4.86±0.32^{cb}
Acidity(%)	2.03±0.06^{c}	1.21±0.17^{ab}	2.41±0.18^{ab}	1.29±0.18^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGi=Fresh ginger

SuGi=Sun dried ginger powder

CaGi=Cabinet dried ginger powder

ShGi=Shade dried ginger powder

4.1.1.2 Proximate composition of ginger powder

Table 4.2 Proximate composition of ginger powder [A,B]

Variable	Sample			
	FGi	**SuGi**	**CaGi**	**ShGi**
Moisture (%)	79.13±0.32^{a}	5.41±0.37^{a}	4.32±0.03^{b}	3.96±0.5^{c}
Ash (%)	1.10±0.17^{b}	1.9±0.14^{b}	1.3±0.51^{ab}	1.01±0.21^{ab}
Protein (%)	2.07±0.6^{ab}	1.63±0.05^{c}	1.67±0.15^{ca}	1.13±0.53^{c}
Fat (%)	2.3±0.26^{ab}	1.03±0.50^{ca}	1.67±0.15^{ca}	1.17±0.15^{a}
Fiber (%)	2.23±0.23^{bc}	1.37±0.23^{ac}	1.26±0.05^{b}	1.3±0.1^{b}
Carbohydrate (%)	17.26±0.44^{b}	11.16±0.79^{ab}	14.32±0.56^{c}	14.13±0.32^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGi=Fresh ginger

SuGi=Sun dried ginger powder

CaGi=Cabinet dried ginger powder

ShGi=Shade dried ginger powder

4.1.1.3 Vitamin and mineral content of ginger powder

Table 4.3 Vitamin and mineral content of fresh ginger and ginger powder [A,B]

Variable	Sample			
	FGi	**SuGi**	**CaGi**	**ShGi**
Vitamin C(mg/100g)	4.9±0.10^{a}	2.27±0.46^{a}	2.57±0.41^{b}	2.23±0.20^{c}
Sodium(mg/100g)	12.97±0.58^{b}	11.02±0.03^{ba}	11.6±0.52^{ba}	9.37±0.05^{ba}
Potassium(mg/100g)	45.75±0.67^{c}	39.6±0.36^{cb}	41.47±0.27^{cb}	39.93±0.15^{c}
Magnesium(mg/100g)	40.33±0.58^{ab}	38.87±0.15^{ca}	38.83±0.15^{ca}	36.36±0.77^{c}
Calcium(mg/100g)	15.57±0.51^{ab}	13.77±0.25^{ba}	13.60±0.53^{ba}	12.67±0.49^{b}
Iron(mg/100g)	0.6±0.10^{ab}	0.533±0.05^{ab}	0.50±0.10^{ab}	0.433±0.15^{b}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGi=Fresh ginger

SuGi=Sun dried ginger powder

CaGi=Cabinet dried ginger powder

ShGi=Shade dried ginger powder

4.1.1.4 Microbial analysis of ginger powder

The result of Total plate count (TPC) and Total Coliforms value of fresh ginger were shown in figure. The TPC value of fresh ginger, were found as 2.0×10^4CFU/g. There was no coliforms found in fresh ginger. The result of Total plate count (TPC) and Total Coliforms value of ginger powder were shown in figure. The TPC value of ginger powder were found as 1.9×10^4CFU/g 1.0×10^4CFU/g .There was no coliforms found in ginger powder.

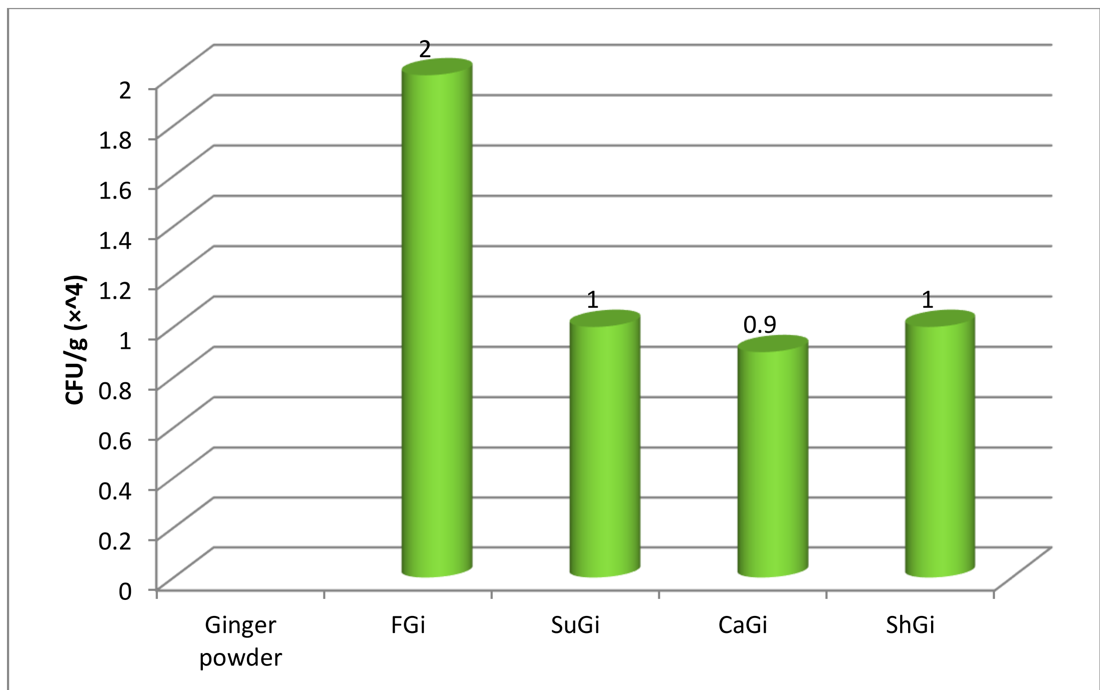


Figure 4.1 Microbial quality of ginger powder

Here,

FGi=Fresh ginger

SuGi=Sun dried ginger powder

CaGi=Cabinet dried ginger powder

ShGi=Shade dried ginger powder.

4.1.1.5 Sensory evulation of ginger powder

Table 4.4 Mean score for color, flavor, Taste, appearance and overall acceptability of Ginger powder stored in plastic bottle[A,B]

Types of sample	Sensory attributes				
	Color	**Flavor**	**Taste**	**Appearance**	**Overall acceptability**
SuGi	8.00±0.20^{a}	8.267±0.33^{a}	8.40±0.40^{a}	7.20±0.33^{b}	8.26±0.26^{a}
CaGi	7.13b±0.26^{c}	6.933±0.40^{c}	7.46±0.45^{c}	7.00±0.33^{c}	7.06±0.27^{c}
ShGi	7.93±0.40^{a}	7.667±0.60^{b}	7.93±0.03^{b}	6.93±0.10^{c}	7.93±0.14^{a}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

SuGi=Sun dried ginger powder

CaGi=Cabinet dried ginger powder

ShGi=Shade dried ginger powder

4.1.2 Ginger Paste

4.1.2.1 The effects of temperature and storage time on the physicochemical parameter of ginger paste packed in plastic bottle.

The changes in TSS, pH and acidity of control and different concentrations preservative Potassium metabisulphate on the ginger paste. The TSS, pH and acidity of controlled ginger paste were 5 to 8°B and 6.49 to 6.11% and 2.03 to 2% respectively.

Table 4.5 The effect of room temperature (30ºC), storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the physicochemical parameter of ginger paste (packed in plastic bottle) from fresh ginger[A,B]:

Storage condition	physicochemical parameter (KMS concentration)		Days of condition			
			0	15	30	45
Room temperature (30ºC)	TSS(º Brix)	500ppm	5±0.00^{a}	6±0.57^{b}	8±0.57^{ab}	8±0.58^{bc}
		750 ppm	5±0.00^{a}	6±0.1^{b}	7.67±0.53^{c}	8±0.10^{ab}
		1000 ppm	5±0.00^{a}	6±0.1^{b}	7.67±0.53^{c}	8±0.10^{ab}
	pH(%)	500 ppm	6.49±0.00^{a}	6.48±0.01^{b}	6.47±0.01^{c}	6.45±0.01^{ab}
		750 ppm	6.17±0.15^{a}	6.16±0.03^{a}	6.12±0.01^{b}	6.11±0.01^{c}
		1000 ppm	6.17±0.15^{a}	6.16±0.03^{a}	6.12±0.01^{b}	6.11±0.01^{c}
	Acidity(%)	500 ppm	2.03±0.05^{a}	2.10±0.03^{b}	2.06±0.01^{a}	2.06±0.01^{ab}
		750 ppm	2.03±0.05^{a}	2.07±0.01^{b}	2.07±0.01^{ab}	2.04±0.01^{ab}
		1000 ppm	2±0.01a^{b}	2±0.01^{ab}	2±0.01^{ab}	2±0.01^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.1.2.2 The effects of temperature and storage time on the proximate composition of ginger paste packed in plastic bottle.

The changes in moisture, ash, protein, fat, fiber and carbohydrate of different concentrations preservative Potassium metabisulphate on the ginger paste. The moisture, ash, protein, fat, fiber and carbohydrate of ginger paste were 79.43 to 79, 1.16 to 0.65, 2.23 to 2.32, 2.27 to 2.02, 2.30 to 2.24 and 17.95 to 16.62 respectively.

Table. 4.6 The effect of room temperature (30ºC) storage time on different concentrations preservative Potassium Metabisulphide (KMS) on the proximate composition of ginger paste (packed in plastic bottle) from fresh ginger [A,B]:

Storage condition	Nutritional composition (KMS concentration)		Days of condition			
			0	15	30	45
Room temperature (30ºC)	Moisture content (%)	500 ppm	79.43 ± 0.40^{a}	78.81 ± 0.09^{b}	78.60 ± 0.10^{ab}	78.40 ± 0.20^{ab}
		750 ppm	79 ± 0.50^{a}	78.39 ± 0.59^{b}	78.90 ± 0.10^{ab}	78.40 ± 0.20^{c}
		1000 ppm	79.4 ± 0.36^{a}	78.99 ± 0.10^{b}	78.60 ± 0.90^{c}	78.38 ± 0.12^{ca}
	Ash content (%)	500 ppm	1.16 ± 0.15^{ba}	0.90 ± 0.10^{ba}	0.82 ± 0.02^{b}	0.82 ± 0.82^{b}
		750ppm	0.96 ± 0.05^{a}	0.73 ± 0.15^{b}	0.67 ± 0.01^{ca}	0.67 ± 0.02^{ab}
		1000 ppm	0.95 ± 0.50^{a}	0.73 ± 0.60^{ab}	0.65 ± 0.01^{ab}	0.65 ± 0.02^{b}
	Protein content (%)	500 ppm	2.23 ± 0.23^{b}	2.47 ± 0.06^{b}	2.47 ± 0.06^{ba}	2.33 ± 0.02^{b}
		750ppm	2.23 ± 0.46^{a}	2.43 ± 0.08^{b}	2.32 ± 0.02^{c}	2.28 ± 0.03^{c}
		1000 ppm	2.23 ± 0.46^{ab}	2.43 ± 0.08^{bc}	2.32 ± 0.02^{ca}	2.28 ± 0.03^{abc}
	Fat content (%)	500 ppm	2.27 ± 0.06^{c}	2.25 ± 0.09^{cb}	2.25 ± 0.05^{cb}	2.16 ± 0.03^{ca}
		750ppm	2.20 ± 0.10^{a}	2.05 ± 0.03^{b}	2.02 ± 0.01^{c}	2.01 ± 0.02^{a}
		1000 ppm	2.10 ± 0.11^{bc}	2.00 ± 0.01^{ab}	2.00 ± 0.11^{a}	2.01 ± 0.02^{abc}
	Fiber content (%)	500 ppm	2.30 ± 0.10^{b}	2.30 ± 0.10^{b}	2.20 ± 0.10^{abc}	2.24 ± 0.10^{abc}
		750ppm	2.13 ± 0.15^{a}	2.07 ± 0.06^{b}	2.03 ± 0.06^{c}	2.12 ± 0.02^{a}
		1000 ppm	2.11 ± 0.10^{a}	2.06 ± 0.11^{b}	2.01 ± 0.06^{c}	2.10 ± 0.02^{c}
	Carbohydrate content (%)	500 ppm	17.95 ± 0.73^{a}	16.95 ± 0.01^{b}	16.96 ± 0.01^{b}	13.35 ± 0.24^{ab}
		750ppm	16.73 ± 0.21^{a}	16.70 ± 0.10^{b}	16.66 ± 0.03^{a}	16.62 ± 0.02^{ca}
		1000 ppm	16.73 ± 0.21^{a}	16.70 ± 0.10^{b}	16.66 ± 0.03^{a}	16.62 ± 0.02^{ca}

[A] Results are means ± standard deviation of triplicates (n=3)

B Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.1.2.3. Changes of Vitamin C content of ginger paste

The result of vitamin C of control ginger paste as well as the different concentration of preservative added ginger paste were shown in the following figure. There was significant ($p<0.05$) difference in the vitamin C content of the selected ginger.

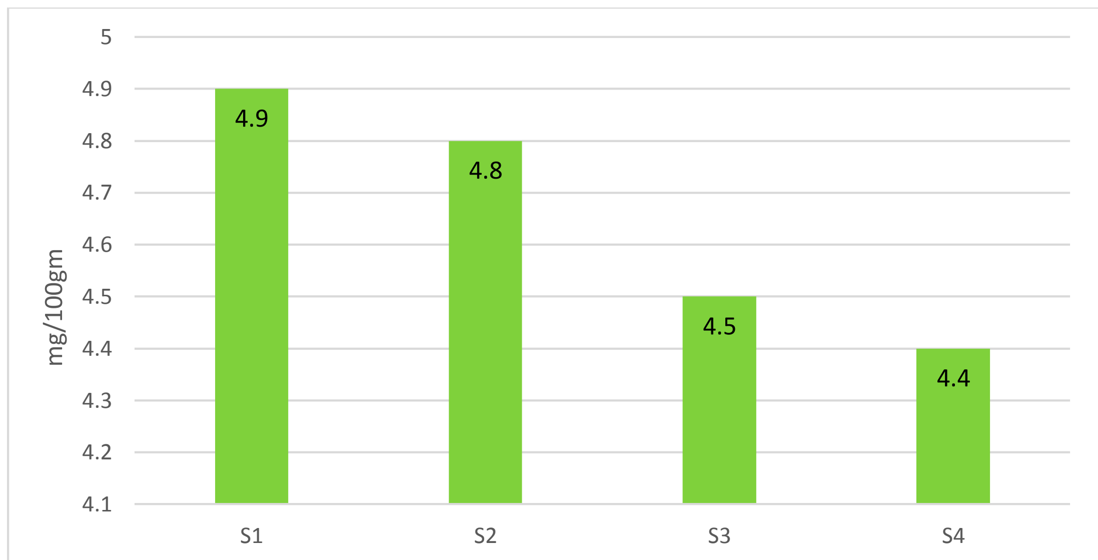


Figure 4.2: Vitamin C content of ginger paste

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.1.2.4 Changes of mineral content of ginger paste

Table 4.7 The effect of room temperature (30ºC), storage time on different concentrations preservative KMS on the mineral contents of ginger paste (packed in plastic bottle) from fresh ginger paste [A,B]:

Storage Condition	Mineral Content (mg/100g)		Days of Condition			
			0	15	30	45
Room Temperature (30ºC)	Na	500 ppm	12.97±0.06^{a}	12.67±0.25^{b}	12.40±0.30^{c}	12.60±0.30 b^{c}
		750 ppm	12.96±0.06^{a}	12.70±0.10^{b}	12.60±0.30^{ab}	12.30±0.25^{c}
		1000 ppm	12.95±0.06^{a}	12.80±0.15^{b}	12.70±0.10^{ab}	12.60±0.45^{ab}
	K	500 ppm	46.22±0.03^{a}	46.20±0.26^{a}	46.53±0.35^{b}	46.33±0.25^{ab}
		750 ppm	46.20±0.00^{a}	46.09±0.08^{b}	46.40±0.30^{c}	46.60±0.30^{ca}
		1000 ppm	46.53±0.35^{b}	46.44±50^{bc}	46.00±0.11^{ab}	46.00±0.11^{abc}
	Mg	500 ppm	0.81±0.02^{a}	0.82±0.02^{b}	0.85±0.03^{ab}	0.86±0.03^{ab}
		750 ppm	0.81±0.01^{a}	0.82±0.02^{b}	0.85±0.02^{c}	0.85±0.03^{ab}
		1000 ppm	0.86±0.03^{ab}	0.85±0.03^{ab}	0.84±0.03^{ab}	0.86±0.05^{ca}
	Ca	500 ppm	0.14±0.05^{a}	0.12±0.04^{b}	0.60±0.30^{ca}	0.50±0.30^{ca}
		750 ppm	0.16±0.01^{a}	0.12±0.02^{b}	0.15±0.03^{ab}	0.15±0.03^{ab}
		1000 ppm	0.15±0.03^{ab}	0.13±0.03^{c}	0.14±0.03^{ab}	0.14±0.03^{ca}
	Fe	500 ppm	0.13±0.01^{a}	0.10±0.00^{b}	0.12±0.01^{ab}	0.12±.01^{ab}
		750 ppm	0.11±0.10^{a}	0.10±0.00^{b}	0.12±0.01^{c}	0.11±0.01^{bc}
		1000 ppm	0.13± 0.10^{a}	0.14±0.10^{b}	0.13±0.10^{ab}	0.13±0.10^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.1.2.5 Microbial analysis of ginger paste

The result of Total plate count (TPC) and Total Coliforms value of ginger paste were shown in figure. The TPC value of ginger paste were found as 2.0×10^{4}CFU/g to 1.0×10^{4}CFU/g. There was no coliforms found in ginger paste.

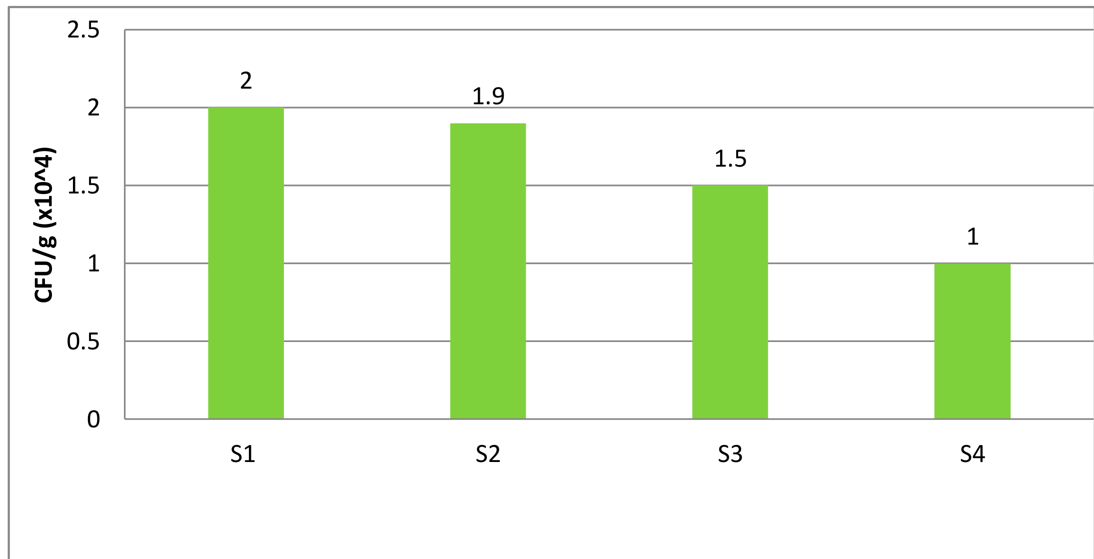


Figure 4.3: Microbial quality of ginger paste

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.1.2.6 Sensory characteristics of ginger paste

Table 4.8 Mean score for color, flavor, Taste, appearance and overall acceptability of Ginger paste stored in plastic bottle[A,B]

Types of Sample (with treatments)	Sensory attributes				
	Color	**Flavor**	**Taste**	**Appearance**	**Overall acceptability**
S1	8.00±0.66^{a}	7.30±1.16^{a}	7.50±0.70^{a}	7.80±0.78^{a}	7.5±0.34^{ab}
S2	7.70±1.25^{b}	7.40±0.96^{b}	7.90±1.10^{b}	8.40±0.69^{b}	6.5±0.87^{ab}
S3	7.70±0.94^{c}	7.60±1.07^{ab}	8.10±0.73^{c}	7.70±0.94^{c}	8.5±0.04^{a}
S4	7.00±1.05ab	7.60±0.84^{a}	7.40±0.84^{ab}	7.80±1.22^{ab}	8.3±0.67^{b}
S5	7.00±0.05^{ab}	7.60±0.84^{ab}	7.40±0.40^{abc}	7.70±0.33^{a}	8.7±0.76^{b}
S6	7.00±0.05^{ab}	7.50±0.30^{ab}	7.30±0.07^{abc}	7.60±0.40^{ab}	5.7±0.60^{ab}
S7	7.70±0.05^{ab}	7.40±0.56^{a}	7.50±0.10^{ab}	7.50±0.30^{ab}	7.8±0.56^{abc}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

S1=Control group

S2=500 ppm Potassium metabisulphate

S3=1000 ppm Potassium metabisulphate

S4=500 ppm Sodium Benzoate

S5=1000 ppm Sodium Benzoate

S6=500 ppm mixed preservative

S7=1000 ppm mixed preservative

4.2. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of garlic powder and paste

4.2.1. Garlic Powder

4.2.1.1 Changes in physicochemical parameter of garlic powder

The TSS, pH and acidity of sun dried, cabinet dried and shade dried contents of ginger powder were 6ºBrix to 5ºBrix, 65.1% to 4.86% and 1.21% to 1.29% respectively in different processing and preservation methods.

Table 4.9 Changes in physicochemical parameter of garlic powder [A,B]

Variable	Sample			
	FGa	**SuGa**	**CaGa**	**ShGa**
TSS (ºBrix)	38±2.51^{b}	35±0.50^{a}	35±0.57^{b}	36±1.58^{a}
pH (%)	5.72±0.15^{ab}	5.56±0.57^{ba}	5.45±0.39^{ba}	4.90±0.10^{c}
Acidity (%)	2.41±0.32^{ab}	0.69±0.01^{a}	0.73±0.02^{a}	0.50±0.10^{ca}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGa=Fresh garlic

SuGa=Sun dried garlic powder

CaGa=Cabinet dried garlic powder

ShGa=Shade dried garlic powder

4.2.1.2 Change of Proximate composition of garlic powder

Table 4.10 Change of Proximate composition of garlic powder [A,B]

Variable	Sample			
	FGa	**SuGa**	**CaGa**	**ShGa**
Moisture (%)	72.83±0.02^{b}	6.18±1.0^{a}	6.06±0.50^{b}	6.13±0.70^{ab}
Ash (%)	0.33±0.50^{ba}	2.7±3.7^{b}	0.56±0.05^{b}	0.46±0.20^{ba}
Protein (%)	6.22±0.19^{ba}	6.2±0.17^{c}	6.83±0.28^{ba}	6.0±0.50^{ca}
Fat (%)	0.50±0.40^{ab}	0.46±0.35^{ca}	0.60±0.43^{ca}	0.53±0.05^{c}
Fiber (%)	2.0±0.10^{ab}	0.90±0.10^{a}	0.96±0.05^{a}	0.70±0.10^{b}
Carbohydrate (%)	32.50±0.50^{b}	31.50±0.50^{a}	32.50±0.50^{ab}	30.66±0.76^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGa=Fresh Garlic

SuGa=Sun dried garlic powder

CaGa=Cabinet dried garlic powder

ShGa=Shade dried garlic powder

4.2.1.3 Vitamin and mineral content of garlic powder

Table 4.11 Changes of Vitamin and mineral content of garlic powder [A,B]

Variable	Sample			
	FGa	**SuGa**	**CaGa**	**ShGa**
Vitamin C(mg/100g)	9.02 ± 0.03^{b}	9.33 ± 2.88^{a}	9.0 ± 0.0^{b}	9.0 ± 0.00^{a}
Sodium(mg/100g)	16.50 ± 0.50^{ba}	15.83 ± 0.28^{a}	16.33 ± 0.57^{a}	14.73 ± 0.25^{a}
Potassium(mg/100g)	4.0 ± 0.01^{ca}	1.60 ± 0.43^{a}	1.06 ± 0.05^{ca}	0.90 ± 0.10^{bc}
Magnesium(mg/100g)	2.03 ± 0.45^{ca}	1.83 ± 0.76^{a}	1.83 ± 0.28^{b}	1.60 ± 0.10^{ab}
Calcium(mg/100g)	1.53 ± 0.50^{ab}	0.66 ± 0.48^{a}	0.80 ± 0.26^{b}	0.60 ± 0.26^{ab}
Iron(mg/100g)	1.70 ± 0.10^{ab}	0.05 ± 0.04^{b}	0.35 ± 0.56^{b}	6.0 ± 0.02^{ca}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGa=Fresh Garlic

SuGa=Sun dried garlic powder

CaGa=Cabinet dried garlic powder

ShGa=Shade dried garlic powder

4.2.1.4. Microbial analysis of garlic powder

The result of Total plate count (TPC) and Total Coliforms value of garlic powder were shown in figure. The TPC value of garlic powder were found as 3×10^4CFU/g. There was no coliforms found in garlic powder.

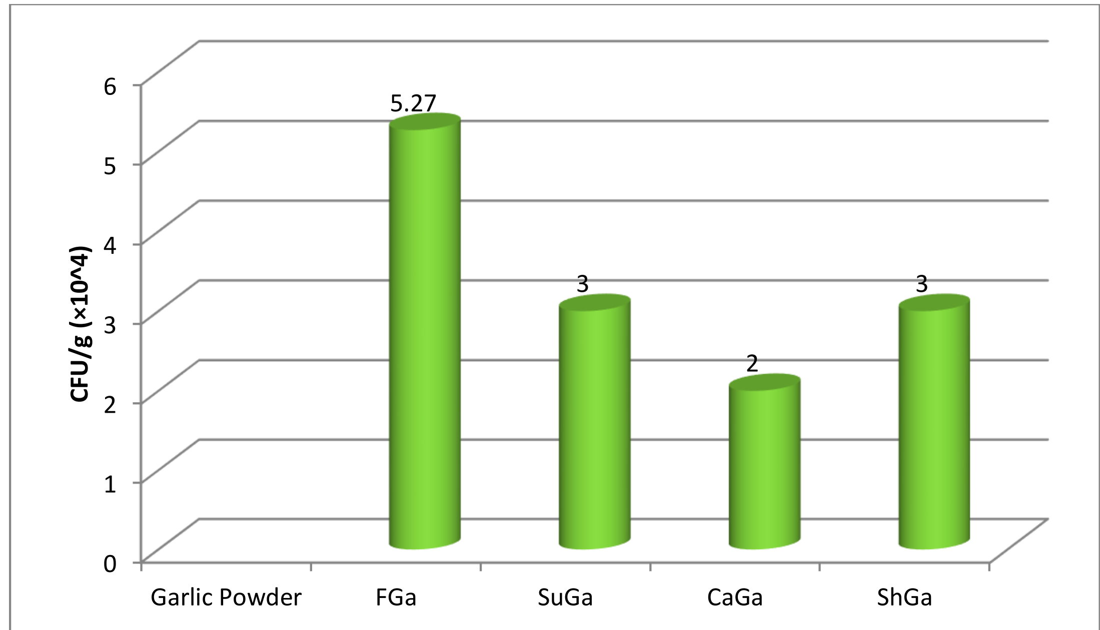


Figure 4.4: Microbial quality of garlic powder

Here,

FGa=Fresh garlic

SuGa=Sun dried garlic powder

CaGa=Cabinet dried garlic powder

ShGa=Shade dried garlic powder

4.2.1. 5 Sensory characteristics of garlic powder

Table 4.12 Mean score for color, flavor, Taste, appearance and overall acceptability of garlic powder stored in plastic bottle[A,B]

Types of sample	Sensory attributes				
	Color	Flavor	Taste	Appearance	Overall acceptability
SuGa	5.8 ± 0.70^{a}	5.5 ± 0.60^{b}	5.2 ± 0.30^{b}	5.3 ± 1.9^{bc}	5.4 ± 1.4^{bc}
CaGa	6.7 ± 0.30^{ab}	5.9 ± 0.60^{b}	5.3 ± 0.40^{bc}	6.1 ± 1.5^{ab}	6.1 ± 1.4^{ab}
ShGa	6.7 ± 1.30^{a}	6.1 ± 1.40^{ab}	5.6 ± 0.40^{c}	6.7 ± 1.3^{a}	6.3 ± 1.5^{a}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

SuGa=Sun dried garlic powder

CaGa=Cabinet dried garlic powder

ShGa=Shade dried garlic powder

4.2.2. Garlic Paste

4.2.2.1 The effects of temperature and storage time on the physicochemical parameter of garlic paste packed in plastic bottle.

The changes in TSS, pH and acidity of control and different concentrations preservative Potassium metabisulphate on the ginger paste. The TSS, pH and acidity of controlled ginger paste were 5 to 8°B and 6.49 to 6.11% and 2.03 to 2% respectively.

Table 4.13 The effect of room temperature (30ºC), storage time on different concentrations preservative Sodium Benzoate on the physicochemical parameter of garlic paste (packed in plastic bottle) from fresh garlic [A,B]:

Storage condition	physicochemical parameter (SB concentration)		Days of condition			
			0	15	30	45
Room temperature (30ºC)	TSS (ºBrix)	500ppm	$40±0.00^{a}$	$40±0.57^{b}$	$42±0.57^{ab}$	$42±0.58^{bc}$
		750 ppm	$40±0.00^{a}$	$43±0.10^{b}$	$41±0.53^{c}$	$41±0.10^{ab}$
		1000 ppm	$40±0.00^{a}$	$41±0.10^{b}$	$43±0.53^{c}$	$43±0.10^{ab}$
	pH (%)	500 ppm	$5.89±0.00^{a}$	$5.90±0.01^{b}$	$5.90±0.01^{c}$	$5.91±0.01^{ab}$
		750 ppm	$5.89±0.15^{a}$	$5.91±0.03^{a}$	$5.93±0.01^{b}$	$5.95±0.01^{c}$
		1000 ppm	$5.89±0.15^{a}$	$5.90±0.03^{a}$	$5.91±0.01^{b}$	$5.91±0.01^{c}$
	Acidity (%)	500 ppm	$2.7±0.05^{a}$	$7.86±0.01^{b}$	$6.65±0.01^{a}$	$5.56±0.05^{ab}$
		750 ppm	$2.7±0.05^{a}$	$7.85±0.03^{b}$	$6.75±0.40^{ab}$	$5.67±0.15^{ab}$
		1000 ppm	$2.5±0.06^{ab}$	$7.86±0.30^{ab}$	$6.84±0.35^{ab}$	$5.56±0.35^{ab}$

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.2.2.2 The effects of temperature and storage time on the proximate composition of garlic paste packed in plastic bottle.

Table 4.14 The effect of room temperature (30ºC), storage time on different concentrations preservative Sodium benzoate on the proximate composition of garlic paste (packed in plastic bottle) from fresh garlic ^{A,B}:

Storage condition	Nutritional composition (SB concentration)		Days of condition			
			0	15	30	45
Room temperature (30ºC)	Moisture content (%)	500 ppm	72.85±0.36^{a}	72.72±0.10^{b}	72.66±0.09^{c}	72.53±0.13^{a}
		750ppm	72.85±0.50^{ab}	72.66±0.30^{b}	72.54±0.30^{ca}	72.21±0.30^{a}
		1000 ppm	72.85±0.36^{ab}	72.83±0.30^{b}	72.32±0.30^{b}	72.26±0.30^{ab}
	Ash content (%)	500 ppm	0.37±0.17^{ab}	0.37±0.10^{ab}	0.38±0.05^{ca}	0.37±0.01^{ca}
		750ppm	0.37±0.05^{ab}	0.37±0.03^{a}	0.37±0.03^{a}	0.37±0.02^{c}
		1000 ppm	0.37±0.17^{ab}	0.37±0 .02^{a}	0.37±0.03^{a}	0.37±0.02^{ab}
	Protein content (%)	500 ppm	6.3±0.23^{ab}	6.6±0.02^{ab}	6.8±0.01^{ca}	6.4±0.03^{a}
		750ppm	6.3±0.46^{b}	6.2±0.25^{b}	6.4±0.21^{ab}	6.0±0.20^{ab}
		1000 ppm	6.3±0.20^{b}	6.0±0.20^{b}	6.2±0.35^{b}	6.8±0.35^{ab}
	Fat content (%)	500 ppm	0.10±0.15^{ab}	0.12±0.020^{b}	0.11±0.01^{ab}	0.13±0.02^{ab}
		750ppm	0.10±0.10^{ab}	0.12±0.30^{b}	0.11±0.30^{ab}	0.13±0.30^{ab}
		1000 ppm	0.10±0.15^{b}	0.12±0.30^{b}	0.11±0.30^{ab}	0.16±0.30^{b}
	Fiber content (%)	500 ppm	2.1±0.15^{b}	2.3±0.05^{b}	2.2±0.00^{ab}	2.1±0.02^{b}
		750ppm	2.1±0.15^{b}	2.2±0.30^{ab}	2.6±0.30^{b}	2.0±0.30^{b}
		1000 ppm	2.1±0.15^{ab}	2.3±0.30^{abc}	2.3±0.40^{ab}	2.2±0.26^{ab}
	Carbohydrate content (%)	500 ppm	33 ±0.23^{ab}	30±0.02^{bc}	31±0.02^{ab}	32 ±0.01^{bc}
		750ppm	32±0.21^{a}	32±0.25^{a}	32±0.30^{ca}	31±0.30^{ca}
		1000 ppm	32.50±0.23^{a}	32±0.03^{a}	32±0.03^{a}	32±0.35^{ab}

^{A} Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.2.2.3 Changes of Vitamin C content of garlic paste

The result of vitamin C of control garlic paste as well as the different concentration of preservative added garlic paste were shown in the following figure. There was significant ($p<0.05$) difference in the vitamin C content of the selected garlic.

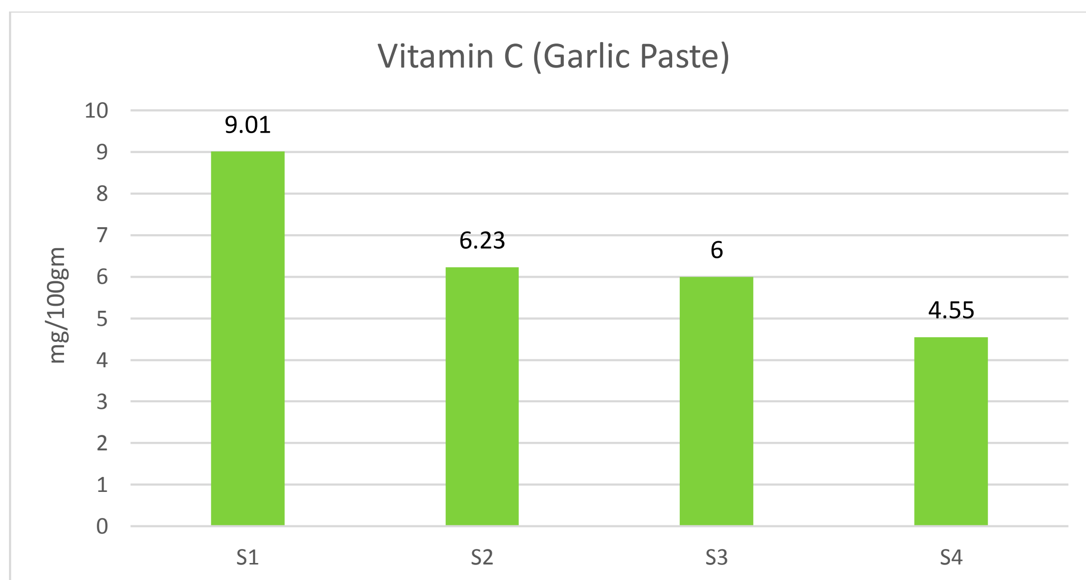


Figure 4.5: Vitamin C content of garlic paste

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.2.2.4 Changes of mineral content of garlic paste

Table 4.15 The effect of room temperature (30ºC), storage time on different concentrations preservative Na Benzoate on the mineral contents of garlic paste (packed in plastic bottle) from fresh garlic paste:

Storage Condition	Mineral Content (mg/100g)		Days of Condition			
			0	15	30	45
Room Temperature (30ºC)	Na	500 ppm	17±0.10[a]	17±0.06[c]	15±0.03[b]	17±0.09[cb]
		750 ppm	10±0.15[a]	16±0.10[b]	16±0.06[b]	14±0.10[b]
		1000 ppm	19±0.06[c]	13±0.10[abc]	17±0.02[a]	14±0.10[abc]
	K	500 ppm	4±0.15[a]	5±0.10[a]	6±0.02[ab]	5±0.04[b]
		750 ppm	4±0.03[ab]	6±0.03[c]	3±0.03[ac]	3±0.03[bc]
		1000 ppm	4.01±0.36[ca]	5.5±0.03[c]	4.06±0.07 bc	4.01±0.12 b
	Mg	500 ppm	2.5±0.21[ca]	2.1±0.05[a]	2.1±0.02[ca]	2.3±0.24[ab]
		750 ppm	2.5±0.03[a]	2.0±0.01[b]	2.0±0.01[b]	2.2±0.21[a]
		1000 ppm	2.4±0.10[b]	2.2±0.73[a]	2.2±0.02[ac]	2.1±0.02[ab]
	Ca	500 ppm	1.8±0.00[a]	1.6±0.00[a]	1.6±0.10[b]	1.5±0.57[b]
		750 ppm	1.5±0.53[c]	1.3±0.57[ab]	1.3±0.10[ab]	1.4±0.58[bc]
		1000 ppm	1.2±0.[10ca]	1.0±0.10[c]	1.2±0.58[ca]	1.1±0.58[cb]
	Fe	500 ppm	1.7±0.00[ab]	1.6±0.15[a]	1.0±0.00[a]	1.0±0.00[a]
		750 ppm	1.7±0.58[ab]	1.0±0.10[b]	1.3±0.03[a]	1.3±0.01[b]
		1000 ppm	1.7±0.01[b]	1.3±0.01[c]	1.2±0.01[c]	1.2±0.01[ab]

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.2.2.5. Microbial analysis of garlic paste.

The result of Total plate count (TPC) and Total Coliforms value of garlic paste were shown in figure. The TPC value of garlic paste were found as 33×10^4CFU/g to 5×10^4CFU/g. There was no coliforms found in garlic paste.

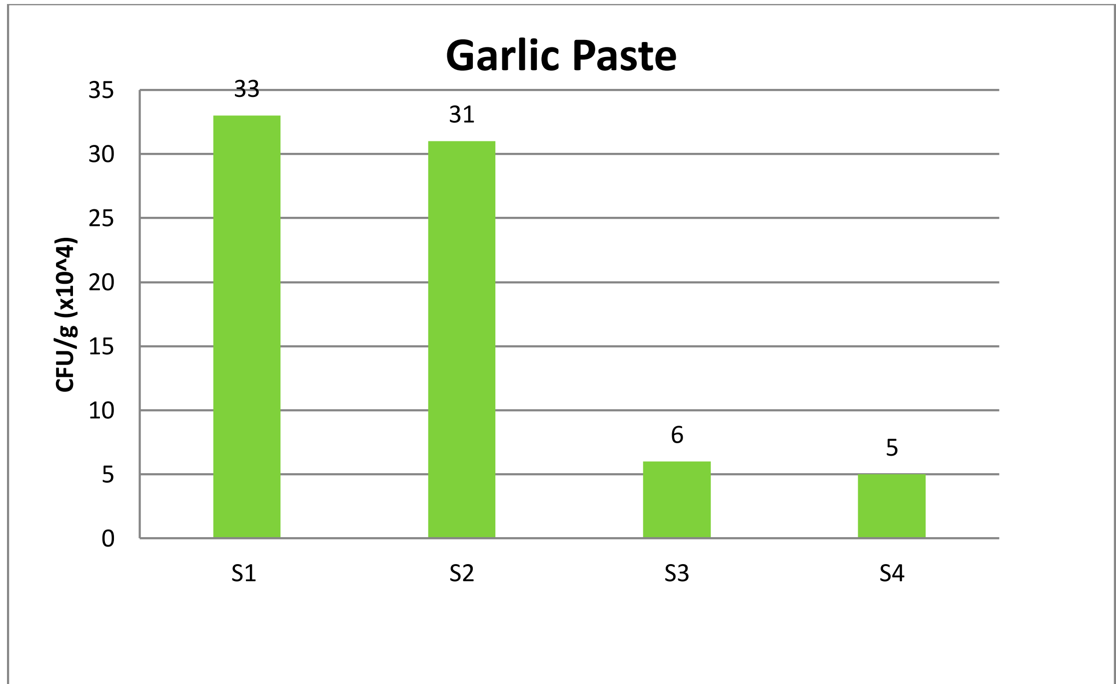


Figure 4.6: Microbial quality of garlic paste.

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.2.2.6 Sensory characteristics of garlic paste

Table 4.16 Mean score for color, flavor, Taste, appearance and overall acceptability of Garlic paste stored in plastic bottle[A,B]

Types of Sample (with treatments)	Sensory attributes				
	Color	Flavor	Taste	Appearance	Overall acceptability
S1	3.30±0.10^{a}	3.1±0.42^{c}	3.2±0.04^{c}	5.9±0.76^{a}	2.8±0.19^{a}
S2	4.7±0.39^{b}	4.7±0.85^{b}	4.4±0.50^{c}	5.8±0.78^{a}	5.1±0.67^{b}
S3	5.00±0.67^{b}	4.8±0.50^{b}	4.5±0.56^{ab}	5.8±0.85^{a}	4.8±0.27^{bc}
S4	4.5±0.43^{b}	4.8±0.59^{b}	5.1±0.70^{bc}	5.7±0.19^{a}	4.5±0.18^{c}
S5	4.5±0.13^{b}	4.6±0.08^{b}	5.1±0.87^{bc}	5.8±0.10^{a}	4.8±0.20^{bc}
S6	4.8±0.50^{b}	4.6±0.08^{b}	4.6±0.90^{abc}	5.7±0.34^{ab}	4.7±0.34^{bc}
S7	4.5±0.59^{b}	4.6±0.67^{b}	5.2±0.79^{abc}	5.8±0.13^{a}	4.8±0.45^{bc}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

S1=Control group

S2=500 ppm Potassium metabisulphate

S3=1000 ppm Potassium metabisulphate

S4=500 ppm Sodium Benzoate

S5=1000 ppm Sodium Benzoate

S6=500 ppm mixed preservative

S7=1000 ppm mixed preservative

4.3. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of green chili powder and paste

4.3.1 Green Chili Powder

4.3.1.1 Changes in physicochemical parameter of green chili powder

Table 4.17 Changes in physicochemical parameter of green chili powder [A,B]

Variable	Sample			
	FGC	**SuGC**	**CaGC**	**ShGC**
TSS(°Brix)	35±0.50^{c}	33 ±0.21^{a}	36±1.0^{a}	34±0.57^{b}
pH(%)	4.60±0.07^{ca}	4.99±0.02^{ba}	4.78±0.02^{ba}	3.49±0.04^{ba}
Acidity(%)	0.5±0.03^{ca}	0.21±0.03^{ab}	0.29±0.02^{ab}	0.94±0.02^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGC=Fresh Green chili

SuGC=Sun dried green chili powder

CaGC=Cabinet dried green chili powder

ShGC=Shade dried green chili powder.

4.3.1.2 Change of Proximate composition of green chili powder

Table 4.18 Change of Proximate composition of green chili powder [A,B]

Variable	Sample			
	FGC	**SuGC**	**CaGC**	**ShGC**
Moisture (%)	85.69±0.74^{c}	8.99±0.08^{a}	7.34±0.11^{b}	8.71±0.26^{a}
Ash (%)	0.824±0.12^{ca}	.80±0.16^{ba}	0.37±0.72^{ba}	0.80±0.71^{b}
Protein (%)	5.83±0.21^{ca}	16.87±0.21^{c}	15.17±0.06^{ca}	15.04±0.20^{cb}
Fat (%)	1.77±0.02^{ab}	5.23±0.15^{a}	5.0±0.06^{ca}	4.83±0.25^{bc}
Fiber (%)	3.27±0.12^{ab}	25.67±0.12^{b}	25.63±0.12 ^{b}	25.33±0.05^{a}
Carbohydrate (%)	43±0.13^{ab}	80.62±0.33^{b}	81.19±0.32^{b}	83.18±0.34^{b}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGC=Fresh green chili

SuGC=Sun dried green chili powder

CaGC=Cabinet dried green chili powder

ShGC=Shade dried green chili powder

4.3.1.3 Changes of Vitamin and mineral content of green chili powder

Table 4.19 Changes of Vitamin and mineral content of green chili powder [A,B]

Variable	Sample			
	FGC	SuGC	CaGC	ShGC
β Carotene(μg/100g)	50±0.30^{c}	49±0.32^{a}	49±0.30^{a}	48±0.30^{b}
Sodium(mg/100g)	3.2±0.07^{abc}	3.03±0.05^{b}	3.1±0.10^{b}	2.7±0.50^{ca}
Potassium(mg/100g)	153±0.34^{ab}	1.05±0.25^{ca}	1.13±0.70^{ca}	1±0.11^{ba}
Magnesium(mg/100g)	11.20±0.68^{ab}	10.16±0.28^{c}	10.53±0.50^{a}	9.36±0.32^{c}
Calcium(mg/100g)	8.1±0.17^{ac}	8.1±0.10^{b}	8.4±0.10^{b}	8.01±0.28^{a}
Iron(mg/100g)	0.5±0.2^{ca}	0.53±0.06^{b}	0.65±0.05^{b}	0.52±0.06^{b}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

FGC=Fresh green chili

SuGC=Sun dried green chili powder

CaGC=Cabinet dried green chili powder

ShGC=Shade dried green chili powder

4.3.1.4 Microbial analysis of green chili powder

The result of Total plate count (TPC) and Total Coliforms value of green Chili powder were shown in figure. The TPC value of green Chili powder were found as 1.88×10^4CFU/g to 2.97×10^4CFU/g. There was no coliforms found in green chili powder.

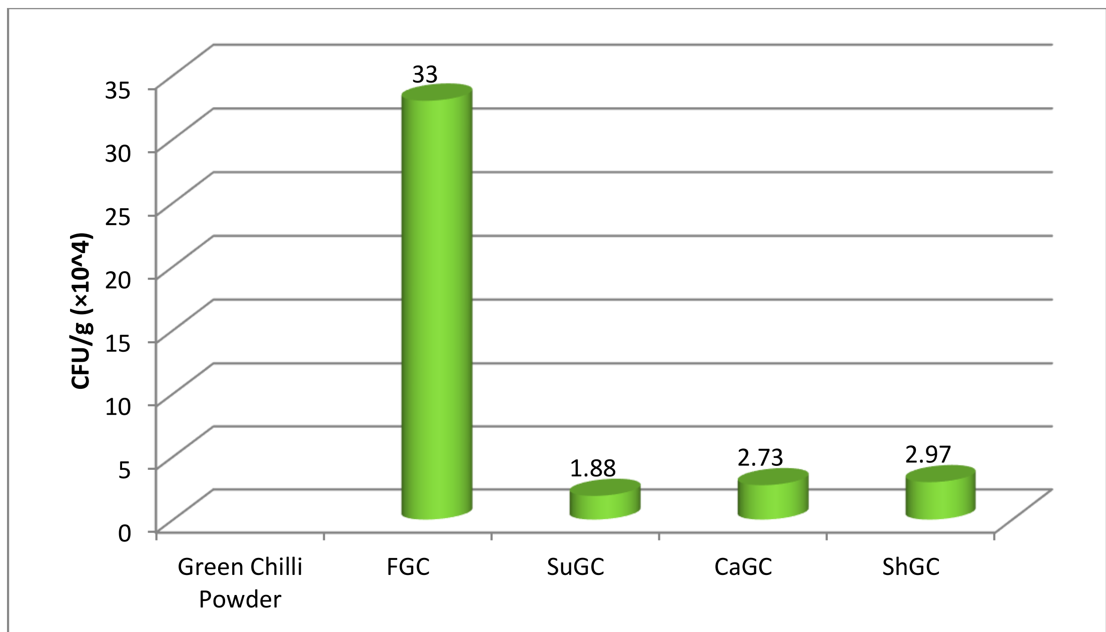


Figure4.7: Microbial quality of green chili powder

Here,

FGC=Fresh green chili

SuGC=Sun dried green chili powder

CaGC=Cabinet dried green chili powder

ShGC=Shade dried green chili powder

4.3.1.5 Sensory characteristics of green chili podwer

Table 4.20 Mean score for color, flavor, Taste, appearance and overall acceptability of green chili powder stored in plastic bottle[A,B]

Types of sample	Sensory attributes				
	Color	Flavor	Taste	Appearance	Overall acceptability
SuGC	7.9 ± 0.23^{a}	8.1 ± 0.12^{a}	7.5 ± 0.48^{a}	7.4 ± 0.45^{a}	8 ± 0.81^{a}
CaGC	7.1 ± 0.66^{b}	7.3 ± 0.20^{b}	6.8 ± 0.13^{b}	6.7 ± 0.15^{b}	7.5 ± 0.49^{b}
ShGC	7.0 ± 0.50^{c}	6.5 ± 0.15^{ab}	6.5 ± 1.15^{ab}	7.0 ± 0.15^{ab}	7.5 ± 0.14^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

SuGC=Sun dried green chili powder

CaGC=Cabinet dried green chili powder

ShGC=Shade dried green chili powder

4.3.2 Green Chili Paste

4.3.2.1 The effects of temperature and storage time on the physicochemical parameter of green chili paste packed in plastic bottle.

The changes in TSS, pH and acidity of control and different concentrations preservative Potassium metabisulphate on the ginger paste. The TSS, pH and acidity of controlled ginger paste were 5 to 8°B and 6.49 to 6.11% and 2.03 to 2% respectively.

Table 4.21 The effect of room temperature (30ºC), storage time on different concentrations preservative mixed preservative (50:50) on the physicochemical parameter of green chili paste (packed in plastic bottle) from fresh green chili paste [A,B]

Storage condition	Physicochemical parameter (KMS:SB concentration)		Days of condition			
			0	15	30	45
Room temperature (30ºC)	TSS (ºBrix)	500 ppm	40±0.57^{a}	40±0.57^{b}	42±0.57^{ab}	42±0.58^{bc}
		750 ppm	40±0.00^{a}	43±0.10^{b}	41±0.53^{c}	41±0.10^{ab}
		1000 ppm	40±0.00^{a}	41±0.10^{b}	43±0.53^{c}	4±0.10^{ab}
	pH (%)	500 ppm	4.56±0.00^{a}	4.55±0.01^{b}	4.60±0.01^{c}	4.60±0.01^{ab}
		750 ppm	4.67±0.15^{a}	4.60±0.03^{a}	4.67±0.01^{b}	4.68±0.01^{c}
		1000 ppm	4.40±0.15^{a}	4.50±0.03^{a}	4.55±0.01^{b}	4.56±0.01^{c}
	Acidity (%)	500 ppm	0.50±0.05^{a}	0.48±0.01^{a}	0.48±0.01^{a}	0.44±0.01^{ab}
		750 ppm	0.51±0.05^{a}	0.50±0.01^{ab}	0.50±0.01^{ab}	0.49±0.01^{ab}
		1000 ppm	0.52±0.01^{ab}	0.50±0.01^{ab}	0.50±0.01^{ab}	0.49±0.01^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.3.2.2 The effects of temperature and storage time on the proximate composition of green chili paste packed in plastic bottle.

Table 4.22 The effect of room temperature (30ºC), storage time on different concentrations preservative mixed preservative (50:50) on the proximate composition of green chili paste (packed in plastic bottle) from fresh green Chili paste [A,B] :

Storage condition	Nutritional composition (KMS:SB concentration)		Daysof condition			
			0	15	30	45
Room temperature (30ºC)	Moisture content (%)	500ppm	85.69±0.40^{a}	85.6±0.09^{b}	85±0.10^{ab}	85±0.20^{ab}
		750ppm	85.6±0.50^{a}	85.5±0.59^{b}	85±0.10^{ab}	84.90±0.20^{c}
		1000 ppm	85.67±0.36^{a}	85.5±0.10^{b}	85.90±0.90^{c}	84.8±0.12^{ca}
	Ash content (%)	500 ppm	0.82±0.15^{ba}	0.82±0.10^{ba}	0.82±0.02^{b}	0.82±0.82^{b}
		750ppm	0.82±0.05^{a}	0.82±0.15^{b}	0.82±0.01^{ca}	0.82±0.02^{ab}
		1000 ppm	0.82±0.5^{a}	0.81 ±0.60^{ab}	0.81±0.01^{ab}	0.81±0.02^{b}
	Protein content (%)	500 ppm	5.83±0 .23^{b}	5.83±0.06^{b}	5.81±0.06^{ba}	6.0±0.02^{b}
		750ppm	5.85±0.46^{a}	5.80±0.08^{b}	5.80±0.02^{c}	5.80±0.03^{c}
		1000 ppm	5.81±0.46^{ab}	5.82±0.08^{bc}	5.81±0.02^{ca}	5.81±0.03^{abc}
	Fat content (%)	500 ppm	1.78±0.06^{c}	1.78±0.09^{cb}	1.77±0.05^{cb}	1.77±0.03^{ca}
		750ppm	1.73±0.10^{a}	1.73±0.03^{b}	1.73±0.01^{c}	1.73±0.02^{a}
		1000 ppm	1.74±0.11^{bc}	1.75±0.01^{ab}	1.74±0.11^{a}	1.74±0.02^{abc}
	Fiber content (%)	500 ppm	3.27±0.10^{b}	3.27±0.10^{b}	3.26±0.10^{abc}	3.26±0.10^{abc}
		750ppm	3.28±0.15^{a}	3.24±0.06^{b}	3.29±0.06^{c}	3.24±0.02^{a}
		1000 ppm	3.23±0.10^{a}	3.21±0.11^{a}	3.21±0.06^{c}	3.20±0.02^{c}
	Carbohydrate content (%)	500 ppm	4.3±0.73^{a}	4.3±0.01^{b}	4.2±0.01^{b}	4.2±0.24^{ab}
		750Ppm	4.1±0.21^{a}	4.5±0.10^{b}	4±0.03^{a}	4±0.02^{ca}
		1000 ppm	4±0.21a	4±0.10^{b}	3.9±0.03^{a}	3.8±0.02^{ca}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.3.2.3. Changes of β-carotene content of green chili paste

The result of β-carotene content of control green chili paste as well as the different concentration of preservative added green chili paste were shown in the following figure. There was significant ($p<0.05$) difference in the β-carotene content of the selected green chili.

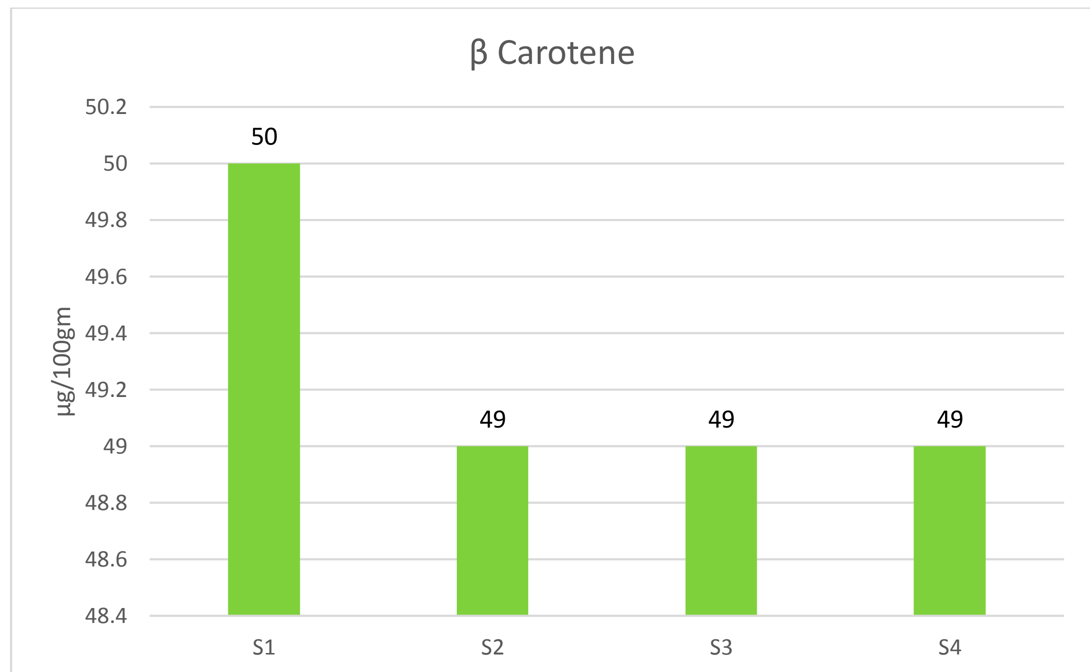


Figure 4.8: β-carotene content of green chili paste

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.3.2.4 Changes of mineral content of green chili paste

4.23 The effect of room temperature (30ºC), storage time on different concentration of preservative mixed preservative (50:50) on the mineral contents of green chili paste (packed in plastic bottle) from fresh green chili paste [A,B] :

Storage Condition	Mineral Content (mg/100g)		Days of Condition			
			0	15	30	45
Room Temperature (30ºC)	Na	500 ppm	3.2±0.15^{a}	3.2±0.06^{b}	3.1±0.01^{ab}	3.1±0.00^{ab}
		750 ppm	3.1±0.10^{b}	3±0.10^{b}	3±0.10^{a}	2.9±0.12^{b}
		1000 ppm	3.2±0.10^{a}	3.1±0.10^{a}	3.1±0.10^{b}	3±0.10^{b}
	K	500 ppm	153±0.10^{a}	153±0.01^{ca}	153±0.01^{ca}	153±0.10^{c}
		750 ppm	153.1±0.10^{ab}	153±0.10^{ab}	152.5±0.00^{b}	152±0.02^{ca}
		1000 ppm	153.2±0.15^{ab}	153±0.01^{ab}	153±0.01^{b}	153±0.01^{c}
	Mg	500 ppm	11.2±0.03^{a}	11.2±0.01^{b}	11.1±0.15^{a}	11.1±0.01^{c}
		750 ppm	11.3±0.00^{a}	11.2±0.15^{a}	11.2±0.58^{cb}	11.2±0.58^{ca}
		1000 ppm	11.5±0.00^{a}	11.5±0.01^{b}	11.5±0.58^{cb}	11.4±0.58^{ca}
	Ca	500 ppm	8.1±0.03^{a}	8.1±0.01^{b}	8±0.01^{c}	8±0.01^{c}
		750 ppm	8.2±0.01^{ab}	8.1±0.00^{b}	8.1±0.10^{ab}	8±0.02^{ca}
		1000 ppm	8.3±0.15^{ab}	8.2±,010^{ab}	8.2±0.01^{ab}	8.1±0.01^{ca}
	Fe	500 ppm	0.5±0.15^{a}	0.5±0.02^{ca}	0.5±0.15^{a}	0.5±0.01^{c}
		750 ppm	0.53±0.10^{ab}	0.52±0.01^{b}	0.52±0.15^{a}	0.52±0.01^{ca}
		1000 ppm	0.52±0.10^{ab}	0.51±0.03^{a}	0.51±0.01^{ca}	0.5±0.01^{ca}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

4.3.2.5. Microbial analysis of green chili paste.

The result of Total plate count (TPC) and Total Coliforms value of green chili paste were shown in figure. The TPC value of green chili were found as 5.27×10^{4}CFU/g to 4.0×10^{4}CFU/g . There was no coliforms found in green chili paste.

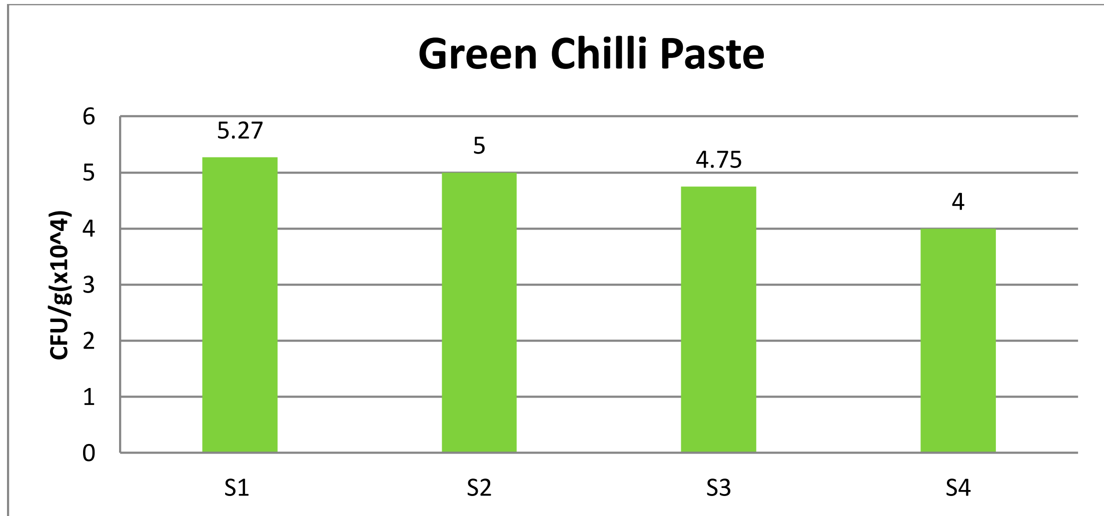


Figure 4.9: Microbial quality of green chili paste.

Here,

S1=Control group

S2=500 ppm Potassium Metabisulphate

S3=500 ppm Sodium Benzoate

S4=500 ppm mix preservative. 50:50

4.3.2.6. Sensory characteristics of green chili paste

Table 4.24 Mean score for color, flavor, Taste, appearance and overall acceptability of green chili paste stored in plastic bottle[A,B]

Types of Sample (with treatments)	Sensory attributes				
	Color	**Flavor**	**Taste**	**Appearance**	**Overall acceptability**
S1	4.4 ± 0.85^{b}	3.8 ± 0.92^{b}	3.5 ± 0.31^{c}	5.9 ± 0.65^{a}	3.8 ± 0.13^{c}
S2	5.1 ± 0.31^{a}	5.6 ± 0.31^{a}	5.5 ± 0.00^{ab}	5.9 ± 0.67^{a}	5.5 ± 0.08^{b}
S3	5.7 ± 0.15^{a}	5.6 ± 0.54^{a}	5.4 ± 0.00^{ab}	5.9 ± 0.45^{a}	5.7 ± 0.89^{ab}
S4	5.6 ± 0.92^{a}	5.6 ± 0.54^{a}	5.6 ± 0.62^{ab}	5.7 ± 0.23^{b}	5.6 ± 0.45^{ab}
S5	5.8 ± 0.31^{a}	5.7 ± 0.15^{a}	5.4 ± 0.54^{ab}	5.8 ± 0.45^{a}	6.0 ± 0.54^{a}
S6	5.7 ± 0.08^{a}	5.7 ± 0.80^{a}	5.1 ± 0.56^{b}	5.7 ± 0.34^{a}	5.6 ± 0.76^{ab}
S7	5.6 ± 0.46^{a}	5.5 ± 0.46^{a}	5.6 ± 0.31^{ab}	$5.9\pm0.44a^{b}$	5.7 ± 0.44^{ab}

[A] Results are means ± standard deviation of triplicates (n=3)

[B] Means followed by different superscript letters in each row are significant different ($p<0.05$).

Here,

S1=Control group

S2=500 ppm Potassium metabisulphate

S3=1000 ppm Potassium metabisulphate

S4=500 ppm Sodium Benzoate

S5=1000 ppm Sodium Benzoate

S6=500 ppm mixed preservative

S7=1000 ppm mixed preservative.

Chapter 5: Discussion

5.1. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of ginger powder and paste

The observation on physicochemical parameter of fresh ginger, ginger powder, ginger paste presented in Table(4.1 to 4.8) revealed that TSS, pH and acidity parameters (Mean ± SD) of fresh ginger, powder and paste was 5 ±0.57ºB, 6.16±0.15%, 2.03±0.06%,6ºB,65.1%,1.21%,5 to 6ºB,6.49 to 6.11%,2.03 to 2.10 respectively.

Thus the pH did not vary much with the period of storage. Similar observations were also made by Ahmed and Shivare (2001) and Ahmed (2004) for ginger paste when the paste was stored in HDPE, PET and glass jars. Lower the pH, the commodity will be more stable against the microbial spoilage. As such the ginger paste was found to be stable against bacterial spoilage for 45 days of storage. Thus broadly our values were in slightly similar with Phoungchandang and Sertwasena (2010), Emehute (2002), Policegoudra and Aradhya (2007), Akhtar et al. (2013) and Rahman et al. (2013).

The data on chemical characteristics of fresh ginger indicated a moisture content of 79.13 per cent in fresh ginger. The data on chemical characteristics ginger powder indicated a moisture content of 5.14 to 3.96 per cent (table 4.2). The initial moisture content of ginger powder and paste was 5.41% to 3.96% and 79.43% to 79.40% by different drying processes and preservation by different concentration. It was slightly reduced during storage for the samples treated with KMS, sodium benzoate and mixed preservative.

It was determined the chemical composition of ginger powder and compared with the chemical composition of fresh ginger. The composition of ginger may vary due to varietal difference, variations in stage of maturity, time elapsed between harvesting and analysis and the growing conditions of the ginger. Moisture content of fresh ginger was 79.5%. Keramat Ali et al., (2001) also reported that in Bangladesh, moisture content of fresh ginger was 80.9%., which was almost similar to this investigation.

In case of ash content of fresh ginger was 1.0%, while the ash content of ginger powder was 4.0%. Keramat Ali et al., (2002) reported that the ash content of Bangladeshi fresh ginger was 1.2%. Pruthi (2001) reported that the ash content of

dried ginger was 5.0%. So the ash content of dried ginger was higher than fresh ginger.

Keramat Ali et al., (2002) reported that protein content in fresh ginger of Bangladeshi was 2.3%. Pruthi (2006) reported that the protein content of dried ginger was 8.1%. This is slightly lower than that found in this investigation. The fat content of fresh ginger and dried ginger were 2.50% and 1.98 % (sun dried), 1.75 % (oven dried), 1.81 % (sun and oven dried) respectively.

The protein content determination is one of the most important and widely used analytical measurements in processing and testing quality of food sample. The results obtained showed that cabinet dried ginger powder has high protein content (6.83%) than sun dried ginger powder and shade dried ginger powder (6.2% and 6.0%) but these values were lower.

The amount of protein in ginger powder was 1.63 to 2.13 percent and the amount of protein in ginger paste was 2.23 to 2.78 percent by different concentration of preservative added.

The amount of protein in fresh ginger was recorded as 2.07 per cent respectively which was near to the value revealed by Shirin and Prakash (2010), Kaushal et al. (2014), Nwaoha et al. (2013) and Dei-Tutu and Risch (1976).

The appreciable amount of carbohydrate is suggesting that they can be ranked as carbohydrate rich spices (Table 4.2). However, the carbohydrate content of cabinet dried ginger powder (32.50%) was higher than sun dried ginger powder and shade dried ginger powder (31.50% and 30.6%), and these values were higher than what was reported by (Ojimelukwe et. al.1999).

Cabinet dried ginger powder showed high fat and crude fiber contents (0.60%and 0.96%, resp.) than sun dried ginger powder and shade dried ginger powder (0.46%; 0.53% and 0.90%,0.70% respectively).The crude fiber content from the three samples was higher than some legumes such as cowpea(Kwanashie et.al. 1992), groundnut seed (Parquet, 1974) and soyabean (Aletorand, 1994).The ash content of sun dried ginger powder was higher than cabinet dried ginger powder and shade dried ginger powder.

The initial vitamin C content of fresh ginger, ginger powder (sun, cabinet and shade dried) and paste (added preservative by different concentration) was 4.9 mg/100g, 2.27mg/100g, 2.57mg/100g, 2.23mg/100g, 4.9mg/100g to 4.40mg/100g. The initial vitamin C of ginger paste was 4.9mg/100g which was slightly reduced during storage for the samples treated with potassium metabisulphate, sodium benzoate and mixed preservative in the room temperature (30ºC).

The mineral analysis of the ginger powder indicated their richness in calcium, magnesium, sodium, potassium, iron. Potassium is the most abundant element found in both varieties. High amount of potassium in the body was reported to increase iron utilization (Adeyeye, 2002) and it is beneficial to people taking diuretics to control hypertension and suff ering from excessive excretion of potassium through the body fluid (Arinathan, 2003). Both sodium and potassium are required to maintain osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth (NRC). The ratio of sodium: potassium (Na: K) in the body is of great concern for the prevention of high blood pressure.ANa:Kratioof1isrecommended (NRC). Since this ratio is lower than 1 in both varieties, their consumptions would be beneficial to hypertensive patients. The level of K, P, Mg, and Na in cabinet dried ginger powder was markedly higher than that of sun dried ginger powder and shade dried ginger powder, sun dried ginger powder had a higher Ca content.

Different types of mineral contents re present of fresh ginger, ginger powder and ginger paste. These are Na, K, Mg, Ca and Fe. For these report mineral content are varied from different types of processing and preservation methods. Fresh ginger mineral contents Na, K, Mg, Ca and Fe are 12.97mg/100g, 45.75mg/100g, 15.57mg/100g, 40.33mg/100g and 0.6mg/100g. Different types of drying process mineral contents are reduced. For the minerals contents, Na content are 11.02mg/100g to 9.37mg/100g, K content are 39.6 to 39mg/100g, Ca content are 13.77 to 12.67mg/100g, Mg content are 38.87 to 36.36mg/100g and Fe content are 0.53 to 0.433mg/100g.

The total plate count for sun dried, cabinet dried, shade dried ginger were found as 1.9×10^4 CFU/g, 0.9×10^4 CFU/g and 1.0×10^4 CFU/g. Then the paste of ginger with different preservatives as 2×10^4 CFU/g, 1.9×10^4 CFU/g and 1.00×10^4 CFU/g.

According to general microbiological safety criteria for foods (Food Administration, Manual version 2, Oct, 1995), the acceptable limit of the total plate count is 5x105 cfu/g for herbs and spices and for the foods that needs further cooking before consumption (Topno et al., 2013).

There was no systematic change in the TSS values of the ginger paste, though in general there was a slight increase in the TSS value during storage (table 4.5). The TSS of ginger paste changed from the initial value of 40ºBrix to a minimum of 40ºBrix and a maximum of 43ºBrix in different packaging conditions after 45 days of storage (Table 4.5). Topno et al. (2013) reported similar results for ginger-garlic paste in retort pouches.

The initial pH of ginger paste was 6.49 which was slightly decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS), (table 4.5). The slightly increase in pH may be due to reduction of ascorbic acid with increasing storage period

The pH of the paste did not vary significantly during the storage which changed from the initial value of 4.56% to between 4.68% packaging conditions. Similar observations were also reported for ginger paste stored in HDPE, PET and glass jars (Ahmed & Shivhare, 2001; Sontakke & Roul, 2007). Lower the pH resulted in more stability against microbial spoilage of the commodity. As such the ginger paste was found to be stable against bacterial spoilage up to 120 days of storage. Previously similar results have been reported for minced ginger during refrigerated storage (Choi, Kim, Lee, & Lee, 2002) and ginger paste undergoing pretreatment and storage conditions (Choi et al., 2012).

The initial Acidity of ginger paste was 2.03% which was highly increased during storage for the samples treated with preservative Potassium metabisulphate (KMS) were observed in the room temperature (30ºC) after 45 days of storage., (table 4.5). Moisture content of ginger paste was 79.43% which was decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS), observed in the room temperature (30ºC) after 45 days of storage. (table4.6).The ash content of ginger paste was 0.37% which was similar during storage for the samples treated with preservative Potassium metabisulphate (KMS), (table 4.6) in the room temperature (30ºC). The highest protein content was 2.47% and the lowest was 2.28% were

observed in the room temperature (30ºC) after 45 days of storage.The highest fat content was 2.10% and the lowest fat was 2.02% were observed in the room temperature (30ºC) after 45 days of storage.Fiber content of ginger paste was 2.30% which was slightly increased during storage for the samples treated with preservative Potassium metabisulphate (KMS), (table 4.6). The carbohydrate content of ginger paste was 17.95% which was slightly decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS), (table 4.6). The highest carbohydrate content was 16.70 % and the lowest carbohydrate content was 16.66% were observed in the room temperature (30ºC) after 45 days of storage.

Na (sodium) content of ginger paste was 12.97mg/100g which was decreased and decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS). K (Potassium) content of ginger paste was 46.22mg/100g which was increased and decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS), were observed in the room temperature (30ºC) after 45 days of storage.Mg (Magnesium) content of ginger paste was 0.81mg/100g which was increased during storage for the samples treated with preservative Potassium metabisulphate (KMS). Ca (Calcium) content of ginger paste was 0.14mg/100g which was increased during storage for the samples treated with preservative Potassium metabisulphate (KMS).Fe (Iron) content of ginger paste was 0.13mg/100g which was decreased during storage for the samples treated with preservative Potassium metabisulphate (KMS), (table 4.7). The highest Fe content was 0.14mg/100g and the lowest Fe content was 0.10mg/100g were observed in the room temperature (30ºC) after 45 days of storage.

5.2. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of garlic powder and paste

The observation on physicochemical parameter of fresh garlic, garlic powder, garlic paste presented in Table(4.9 to 4.16) revealed that TSS, pH and acidity parameters (Mean ± SD) of fresh garlic, powder and paste was 38ºB, 5.72%, 2.41%, 35ºB, 4.90%, 0.73%, 40 to 43ºB, 5.89 to 5.96%, 2.7 to 2.0% respectively.

The data on chemical characteristics of fresh garlic indicated a moisture content of 72.43 per cent in fresh garlic.The data on chemical characteristics garlic powder indicated a moisture content of 6.18 to 6.13 per cent (table 4.8.2 to 4.8.11).

Vitamin C content of fresh garlic, garlic powder (sun, cabinet and shade dried) and garlic paste (added preservative by different concentration) was 9.02mg/100g, 9.33mg/100g, 9.0mg/100g,9.0mg/100g and 9.01 to 2.75mg/100g (figure 4.2, 4.12.1 4.12.3). The initial vitamin C content of garlic paste was 9.01mg/100g which was slightly reduced during storage for the samples treated with KMS, SB and MP (figure 4.2). The highest vitamin C was 9.01mg/100g and the lowest vitamin C was 4.2mg/100g were observed in the room temperature (30ºC).

The total plate count of garlic for sun dried, cabinet dried, shade dried and paste with different preservative were 33×10^4 CFU/g, 3×10^4 CFU/g, 2.27×10^4 CFU/g, 2.0×10^4CFU/g, 31×10^4 CFU/g respectively.

The physico-chemical characteristics of fresh garlic samples, initial moisture content (72.85%, wb), total soluble solids (40ºCBrix), acidity (0.50%) and ascorbic acid (9 mg/100 g), were recorded before drying and have been shown in Table 4.5 to 4.7. Similar results were reported by Casado et al. (2004), Ahmed et al. (2001), Madamba et al. (1996), Choudhury (1979) and Flores (1954). They observed that moisture content of fresh peeled garlic cloves ranges from (60-80%, wb) and (7.8% to 204%, db).

The interaction effects between the different slices size and drying methods were found non-significant. The minimum moisture content (72.21%) was observed, whereas maximum (72.85%) was observed. Slightly similar results have been reported by Madamba et al. (1993) in his experiment of determining the moisture content of garlic slices.

The interaction effects between the different slices size and drying methods were found significant. The highest ascorbic acid content (6.23 mg/100 g) was recorded, whereas the lowest ascorbic acid content (4.55 mg/100 g) was recorded. The present findings are supported by Sangwan et al. (2010) and Bib et al. (2008). 0

TSS of garlic paste was 40 which was slightly increased during storage for the samples treated with preservative sodium benzoate (SB) observed in the room temperature (30ºC) after 45 days of storage. pH of garlic paste was 5.89 which was slightly increased during storage for the samples treated with preservative sodium benzoate(SB) observed in the room temperature (30ºC) after 45 days of storage.

Acidity of garlic paste was 2.7% which was highly increased during storage for the samples treated with preservative sodium benzoate (SB), (table 4.13). The highest acidity was 7.85% and the lowest acidity was 5.56% were observed in the room temperature (30ºC) after 45 days of storage.

Moisture content of garlic paste was 72.85% which was decreased during storage for the samples treated with preservative sodium benzoate (SB). The highest moisture content was 72.83 and the lowest moisture content was 72.53% were observed in the room temperature (30ºC) after 45 days of storage.Ash content of garlic paste was 0.37% which was similar during storage for the samples treated with preservative sodium benzoate (SB). Protein content of garlic paste was 6.3% which was slightly increased during storage for the samples treated with preservative sodium benzoate (SB). Fat content of garlic paste was 0.10% which was slightly increased during storage for the samples treated with preservative sodium benzoate (SB) observed in the room temperature (30ºC) after 45 days of storage.Fiber content of garlic paste was 2.1% which was slightly increased during storage for the samples treated with preservative sodium benzoate (SB).Carbohydrate content of garlic paste was 33% which was slightly increased during storage for the samples treated with preservative sodium benzoate (SB) observed in the room temperature (30ºC) after 45 days of storage. (table4.14).

The initial Na (sodium) content of garlic paste was 17mg/100g which was increased and decreased during storage for the samples treated with preservative sodium benzoate (SB). The initial K (Potassium) content of garlic paste was 4mg/100g which was increased and decreased during storage for the samples treated with preservative sodium benzoate (SB). The initial Mg (Magnesium) content of garlic paste was 2.5mg/100g which was decreased during storage for the samples treated with preservative sodium benzoate (SB). The initial Ca (Calsium) content of garlic paste was 1.8mg/100g which was decreased during storage for the samples treated with preservative sodium benzoate (SB). The initial Fe (Iron) content of garlic paste was 1.7mg/100g which was decreased during storage for the samples treated with preservative sodium benzoate (SB), (table 4.15).

Colour, aroma, taste and texture scores observed decreasing trend during dehydration of garlic powder. The organoleptic parameters of garlic powder were significantly

affected by different slices size, drying methods and their combinations. Among the various treatment combinations the better results were obtained in table 4.16. Dhingra et al. (2006), Rennie et al. (2001) and Tulasidas et al. (1995) had reported the similar findings.

5.3. Physicochemical parameter, proximate composition, vitamin content, mineral, microbial changes, sensory characteristics of green chili powder and paste

The fresh green chili was analyzed for moisture, protein, fat, ash and vitamin C and these results are presented in (Table 4.17 to 4.19). The fresh green chilli contained 85.69% moisture, 5.83 % protein, 1.77 % fat, 0.824 % Ash, 9.02 mg per 100g of vitamin C. Fiber 3.27% and reducing sugar 6.15%. The results reported by Srivestava et al., (1994) were similar to the proximate chemical composition of fresh green chilli contained 85.5 % moisture, 5.4 % protein, 1.1 % fat, 1.2 % mineral, 110 mg per % of vitamin C. The small variation may be due to varietal difference, soil property, growing condition, harvesting period, maturity stage, agro-ecological condition and methods of analysis.

The moisture was found in all green chilli powders range from 7.34- 9.53%.The results were agreement with reported by Krishnamurthy and Natarajan (1973). The ash content of green chilli powders was significantly different among all the samples ($P \leq 0.05$). The finding was agreed with Raina et al. (1996) who found that it was ranged from 4.53 to 7.39 %.The protein content was also found significantly different among the samples ($P \leq 0.05$). The results were presented varied from 14.60 and 16.85%. It was noticed that protein was also reported 15.4% in dry chilli per 100 g by Srivastava et al. (1994) within range to our findings. The fat content of green chilli powder were found moreless similar to reported (6.2%) by Srivastava et al. (1994). The ascorbic acid contents of all of dried green chilli found significantly different among the samples ($P \leq 0.05$). The ascorbic acid contents of all dried green chilli varied between 70.57 and 165.20 mg/100 g. The variations were due to difference in treatments, preparation and drying methods applied.

The protein, fat, fiber, reducing sugar and vitamin C of dried chilli were significantly different among the varieties ($P < 0.05$), but moisture, ash and capsicum were not significantly similar among the varieties ($P < 0.05$) due to varietal changes.

The overall results of proximate chemical composition of fresh green chilli similar to reported by Srivestava and Sanjeev (1994) i.e. 85.5% moisture, 5.4% protein, 1.1% fat, 1.2% mineral, 110 mg per % of vitamin C. Singh et al., (2015) has reported that 86.3-87.5% moisture, 1.4-2.3% protein, 0.9-1.5% fat, 1.02-1.2% mineral and 98-104 mg per % of vitamin C. Kumar et al. (2012) also reported that the composition of green chilli viz. Moisture content (98-92%), Ash (0.55-0.65%), Reducing sugar (2.8-3.6 g /100 g), Ascorbic acid 23.25-29.33 mg/100 g). were agreed with our finding. The slight variations were observed due to varietal difference, soil property, and growing condition, harvesting period, maturity stage, agro-ecological condition and methods of analysis.

The pH of green chilli powders are presented in Table 4.17. The results ranged between 3.49- 4.99. The shade drying sample was lower in pH values than the other drying samples. Finding result was agreed with Toontom et al. (2012) who reported that the pH value of all green chili powder varied between 3.21 and 4.84.

The acidity content in green chilli powders were ranging between 0.21-0.94 percent. The results were presented in Table 4.17. Sun drying sample was lower in acidity values than the cabinet and shade dried samples. B-Carotene is the main vitamin present in chilli. Finding result was agreed with Toontom et al. (2012) who reported that the Total Acidity ranged from 0.15 to 0.59%.

The moisture content in all green chilli powders ranged from 7.34- 8.99%. The high moisture content was found on lyophilize green chilli and the low was found on Tray green chilli powders. The results were agreement with reported by Krishnamurthy and Natarajan (1973) who reported that the moisture content of green chilli powders ranged 8-10%. Also our finding was agreed with Singh et al. (2015).

The results were more or less similar to those reported by Raina and Usha, (1996) who noticed that the ash content ranging from 0.37 to 0.80% in green chilli powder. Similarly, Lauhadia and Kulkarni (1978) who found that the ash content was 5.60%.

Also finding was more than that with Singh et al. (2015). Who noted that the ash content was ranged from 3.9- 4.8%.

The results of green chilli powder are presented in Table 4.18. The result ranged between 4.83 -5.23%. The results were more or less similar to those reported by Srivestava and Sanjeev (1994) who showed that is fat (6.2%) in dry chilli per 100 gm. Also our finding results were agreed with Singh et al. (2015) who found that the fat content in green chilli powders between 3.7- 4.3%.

The protein content in green chilli powders were ranging between 15.04-16.87%. The results are presented in Table 4.8. The results were agreed with Srivestava and Sanjeev (1994) who reported that the protein content was 15.4%. There is significant ($P < 0.05$) effect between all drying methods due to drying method and varieties in green chilli powders sample.

The observation on physicochemical parameter of fresh garlic, garlic powder, garlic paste presented in Table(4.17 to 4.24) revealed that TSS, pH and acidity parameters (Mean ± SD) of fresh garlic, powder and paste was 35ºB, 4.60%, 0.50%, 33ºB, 4.3.49%, 0.94%, 35 to 37ºB, 4.60 to 4.30%, 0.50 to 0.52% respectively.

The data on chemical characteristics of fresh green chili indicated a moisture content of 85.69 per cent in fresh green chili. The data on chemical characteristics green chili powder indicated a moisture content of 8.99 to 8.71 per cent (table 4.8.2 to 4.8.11).

The protein, fat, fiber, carbohydrate of dried chili were significantly different among the varieties ($P < 0.05$), but moisture, ash and capsicum were not significantly similar among the varieties ($P < 0.05$) due to varietal changes.

Carotenoid plays a positive role in epithelization process and stimulates the cell cycle progression of the fibroblasts (Stivala et al., 1996). Carotenoid performs as photo protective agents and may lower the risk of sunburn, photo-allergy and even some kinds of skin cancer (Lee et al.,2000) Table 4.19 and figure 4.8 shows that no significant difference found between β-carotene content of both species. β-carotene content found in the green chilli powder ranged from 48 to 50 μg/100g whereas in the green chilli paste ranged from 49 to 50 μg/100g. Results are in line with a study reported carotenoid content of green chilli varies form 0.813.82mg/100g (Starthy and Nosova, 1982).The initial β-Carotene content of fresh green Chili, green Chili powder

(sun, cabinet and shade dried) and green Chili paste (added preservative by different concentration) was 50µg/100g, 49µg/100g, 49µg/100g,50µg/100g to 49.5µg/100g (figure 4.3, table 4.12.1,4.12.4) . The initial β-Carotene content of green Chili paste was 50µg/100g which was slightly reduced during storage for the samples treated with KMS, SB and MP (figure 4.3). The highest β-Carotene was 50µg/100g and the lowest β-Carotene was 48.5µg/100g were observed in the room temperature (30ºC).

The initial TSS of green chili paste was 40 which was slightly increased during storage for the samples treated with preservative Potassium metabisulphate: sodium benzoate (KMS:SB).The highest pH was 4.68 and the lowest pH was 4.55 were observed in the room temperature (30ºC) after 45 days of storage.The slightly increase in pH may be due to reduction of ascorbic acid with increasing storage period. The highest acidity was 0.52% and the lowest acidity was 0.48% were observed in the room temperature (30ºC) after 45 days of storage.

The highest moisture content was 85.0% and the lowest moisture content was 85.60% were observed in the room temperature (30ºC) after 45 days of storage. The initial ash content of green chili paste was 0.82% which was similar during storage for the samples treated with preservative potassium metabisulphate: sodium benzoate (KMS:SB), (table 4.22), in the room temperature (30ºC) after 45 days of storage. The highest protein content was 6.0% and the lowest protein content was 5.80% were observed in the room temperature (30ºC) after 45 days of storage.The highest fat content was 1.77% and the lowest fat was 1.73% were observed in the room temperature (30ºC) after 45 days of storage.The highest fiber content was 3.29% and the lowest fiber content was 3.20% were observed in the room temperature (30ºC) after 45 days of storage.The initial carbohydrate content of green chili paste was 4.3% which was slightly increased during storage for the samples treated with preservative potassium metabisulphate: sodium benzoate (KMS:SB) , (table 4.22).

The highest Na content was 3.2mg/100g and the lowest Na content was 2.9mg/100g were observed in the room temperature (30ºC) after 45 days of storage. The highest K content was 153mg/100g and the lowest K content was 152mg/100g were observed in the room temperature (30ºC) after 45 days of storage.The highest Mg content was 11.5mg/100g and the lowest Mg content was 11.1mg/100g were observed in the room temperature (30ºC) after 45 days of storage.The initial Ca (Calsium) content of green

chili paste was 8.1mg/100g which was slightly increased during storage for the samples treated with preservative potassium metabisulphate: sodium benzoate (KMS:SB), (table 4.23). The initial Fe (Iron) content of green chili paste was 0.5mg/100g which was increased during storage for the samples treated with preservative potassium metabisulphate: sodium benzoate (KMS:SB), observed in the room temperature (30ºC) after 45 days of storage (table 4.23).

For the green Chili total plate count were 5.2×10^4 CFU/g,1.88×10^4 CFU/g,2.97×10^4 CFU/g,5.27×10^4 CFU/g respectively. The changes of total bacterial count (TBC) of the ginger paste during the period of storage. It was observed that TBC of the paste changed from the initial value of 1.333±0.254x105 cfu/g to 7±1x105cfu/g in different packaging conditions. According to general microbiological safety criteria for foods (Food Administration, Manual version 2, Oct, 1995), the acceptable limit of the total plate count is 5x105 cfu/g for herbs and spices and for the foods that needs further cooking before consumption. It was observed that all the samples in cold room were within acceptable limit except sample in HDPE on 120th day. Similarly, the samples in different packaging materials at room temperature were not acceptable at the end of storage.

Chapter 6: Conclusion

Spices are important group of agricultural commodities, because of their taste and aroma but they are widely used to Flavor the food preparations. Spices do not have much nutritive value but the importance of spice in daily diet is due to the fact that they enhance the aroma and Flavor of food preparations. There is lot of heterogeneity found with respect to the plant parts used. Among various indigenous spices of Bangladesh but Ginger, Garlic and Green Chili are common and popular. Availability of this vital source of nutrients largly depends on processing and preservation methods as different storage condition affect the quality. From this study quality changes of sun dried, cabinet dried, shade dried, paste products treatment with preservatives Ginger, Garlic and Green Chili was determined. Result showed that processing and preservation method had significant effects on the quality of the spices ($p<0.05$). Drying processing demonstrated efficient method of spices processing in terms of the retention of protein, fat, fiber and carbohydrate value and reduction in the moisture and ash content. Paste products with preservatives demonstrated efficient methods in term of the retention of mineral content. From this study, we can easily select the best possible preservation methods for spices. This will help the consumer for safe consumption throughout the period of storage and gives clear idea to the person associated with fish business about the preservation method which one they need to follow or apply for their products. The knowledge emerged from the study will improve the preservative strategies of spices and thus prolong the shelf life of one of the commercially important food commodities in the topics.

Chapter 7: Recommendation and Future perspectives

The global consumption of spices and spices products has greatly increased during recent decades, due to a number of distinct factors. Foremost among these factors is the growing knowledge that spices constitute an important and healthy part of the human diet, mainly owing to the presence of antioxidant which play an important role in human health.

Present study is conducted to investigate the quality changes of a traditionally sun dried, cabinet dried, shade dried and paste preserved with preservatives the spices. The research work need to be carried out all fresh spices.

However, there were some limitation in this study as storage time may affect the rate of loss of quality and shelf life of spices. Antioxidant, volatile compound are not analyzed in this studies. Studies of potential carcinogenic hazards associated with the spices in different processing and preservation methods were not identified.

References

Adeyeye EI. 2002. “Determination of the chemical composition of the nutritionally valuable parts of male and female common West African fresh water crab Sudananautes africanus,” International Journal of Food Sciences and Nutrition, vol. 53, no. 3, pp.189–196.

Ahmed J and Shivhare US. 2001. Thermal Kinetics of Color Change, Rheology, and Storage Characteristics of Garlic Puree/Paste. Journal of Food Science 66(5): 754-757. http://dx.doi.org/10.1111/jfds.2001.66.issue-5.

Ahmed J, Pawanpreet and Shivhare, U. S. 2001. Physico-chemical and storage characteristics of garlic paste, Journal of Food Processing and Preservation Volume 25, Issue 1 page 15–23.

Ahmed J, Preet P, Kumar S, 2002. Effect of processing temperature and storage on the color of garlic paste. Journal of Food Science and Technology, 39 (3): 265-267.

Ahmed J, Shivhare US and Singh P. 2004. Color kinetics and rheology of coriander leaf puree and storage characteristics of the paste. Food Chemistry 84: 605–611.

Ahmed J. 2004. Rheological behaviour and colour changes of ginger paste during storage. International Journal of Food Science and Technology. 39: 325-330.

Akhtar A, Dash PK and Mannan A. 2013. Physico- chemical characterization and product development from ginger (Zingiber officinale). Germplasm Available in South Western Region of Bangladesh. IOSR Journal of Agriculture and Veterinary Science. 5: 53-62.

Akhtar J, Omre PK, & Alam, MA. 2015. Effect on quality of developed ginger-garlic paste during storage. International Journal of Applied and Pure Science and Agriculture, 1, 32–41.

Akpata MI and Miachi OE. 2001. “Proximate composition and selected functional properties of Deuterium microcarpum”, Plant Foods for Human Nutrition, vol.56, no.4, pp.297–302,

Alam MM. 2003. Studies on the processing and preservation of turmeric paste. A thesis, submitted to the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh.

Altman RD and Macrcussen KC. 2001. Effects of a ginger extract on knee pain in patients with osteoarthritis. Journal of Phytomedicine. 44: 2531-2538.

Ambrose CP and Sreenarayanan VV. 1998. Studies on the dehydration of garlic. Journal of Food Science and Technology 35: 242-244.

Anonymous. 1991. Processing of Chilies - a Scientific method, Spice India, 4(2): 7.

AOAC, 2000. Official method of Analysis of the Association of Official Analytical Chemist. 11th Ed. Washington, D. C.

AOAC, 2004. Official method of Analysis of the Association of Official Analytical Chemist, Hortwits W(ed). Association of Official Analytical Chemists, Washington, D. C. US.

AOAC. 2016. Official Methods of Analysis. 20th ed., Association of Official Analytical Chemists, Arlington VA. pp. 1058-1059.

Arinathan V, Mohan VR and Britto AJ de. 2003. "Chemical composition of certain tribal pulses in South India," International Journal of Food Sciences and Nutrition, vol.54,no.3,pp. 209–217.

Arya PS. 2001. Ginger Production Technology. Kalyani Publishers New Delhi.169p.

Augusti KT. 1976. Therapeutic values of onion and garlic. Indian J. Exp. Boil. 64:334-336.

Augusti KT. 1977. hypocholesterolaemic effect of garlic (Allium sativum L.) Indian J. Exp. Boil. 15(6): 489-790.

Avila GT. 1997. Post harvest management in bulb-producing vegetables. Conditions for the artificial drying of garlic. Avances-en-Horticultura., 2 (1): pp. 25-35; 32 ref.

Avila GT. 1998. Variables for estimating the best time for drying garlic (*Allium sativum L.*) bulbs.Avances-en-Horticultura. 3(1): pp.12-18; 17 ref.

Baranowski JD. 1985. Storage Stability of a Processed Ginger Paste. Journal of Food Science 50: 932-933.

BBS (Bangladesh Bureau of Statistics) .2018. Yearbook of Agricultural Statistics of Bangladesh, 2017. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 1999. Yearbook of Agricultural Statistics of Bangladesh Bangladesh, 1998. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2005. Yearbook of Agricultural Statistics of Bangladesh Bangladesh, 2004. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2014. Yearbook of Agricultural Statistics of Bangladesh Bangladesh, 2013. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2015. Yearbook of Agricultural Statistics of Bangladesh Bangladesh, 2014. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2016. Yearbook of Agricultural Statistics of Bangladesh Bangladesh, 2014. Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS. 2004. Monthly Statistical Bulletin. Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning. Govt. of the people's Republic of Bangladesh. P. 57.

Beaglehole R. 1997. Garlic Flavor, nor cardioprotecin Lancet 348 (9036) 1186-1187 New Zealand.

Bhuyan S and Prasad S. 1990. Drying characteristics of ginger and development of a small capacity dryer. In Proceedings of the 4th International Agricultural Mechanization and Energy Congress, Adana. Turke.

Bib, Nizakat, Khattak, Amal Bad shah, Aurang, Zeb, and Zahid, Mehmood. 2008. Irradiation and packaging Food safety aspects and shelf life extension of solar dried garlic (Allium sativum L.) Powder. American Journal of Food technology 3(2): pp.118-126.

Cabrera-Rabi L, Morewa HT and Lopez LM. 1987. Influence of Some Drying Variants on the Quality of Dehydrated Onion (var. Texas Early Granex).Technolozia Quimica, 8(3), pp. 77-82 and 93-94 (FSTA 88-05-J0133).

Camacho EH and Brescia A. 2009. The Australian ginger industry: Overview of Market Trends and Opportunities. Ginger: The Genus Zingiber. CRC Press, Florida, U.S.A. http://www.daff.qld.gov.au/data/assets.

Casado FJ, Lopez A, Rejano L, Sanchez AH and Montano A. 2004. Nutritional composition of commercial pickled garlic. European Food Research and Technology, Volume 219, Number 4, September, pp. 355-359 (5).

Chaiyakunapruk N, Kitikannakorn N, Nathisuwan S, Leeprakobboon K, Leelasettagool C. 2006. The efficacy of ginger for the prevention of postoperative nausea and vomiting: a meta-analysis. Am. J. Obstet. Gynecol .194(1):95-99.

Charles V and Charles SX. 1992. The use and efficacy of Azadirachta India ADR (Neem) and Curcuma Longa (turmeric) in scabies. Tropical and Geographical Medicine, 44 (1&2): 178-181.

Chen XD and Mujumdar A. 2008.Drying Technologies in Food Processing, WileyBlackwell.

Choi EJ, Lee KA, Kim BS, & Ku KH. 2012. Effect of pre-treatment and storage conditions on the quality characteristics of ginger paste. Preventive Nutrition and Food Science, 17, 46–52. http://dx.doi.org/10.3746/pnf.2012.17.1.046.

Choi MS, Kim DH, Lee KH, & Lee YC. 2002. Effect of additives on quality attributes of minced ginger during refrigerated storage. Korean Society of Food Science and Technology, 34, 1048–1056.

Chopra KN, Chopra IC, K. Handa, K., and. Kapur,L. D. 1958. Chopra's Ingredients Drugs of India.2nd ed. UN Dhua Sons. Private Ltd. Calcutta ppm. 271-274.

Choudhary B and Flores AF. 1979. Chemical constituents of garlic Vegetables National Book Trust, New Delhi (India), pages 103-105.

Chrubasik S, Pittler M, Roufogalis B. 2005. Zingiber is rhizoma: a comprehensive review on the ginger effect and efficacy profiles. Phytomedicine, 12:684–701.doi:10.1016/j.phymed.2004.07.009PMID: 16194058.

Codex Alimentarius Commission (Codex) 1995. Code of Hygienic Practices for Spices and Dried Aromatic Plants. CAC/RCP 42–1995.

Codex Alimentarius Commission. Joint FAO/WHO Food Standards Programme. World Health Organization, Geneva Switzerland.

Cruess WV. 1958. Commercial Fruit and Vegetable Products. McGraw Hill Book Company Inc., New York.

Damayanti KS, Radha R and Kalyanaraman. 1983. Proceedings of the national seminar.

Dei -Tutu J and Risch E. 1976. Studies on the composition of some Ghanaian ginger samples. Food Research Institute. 9: 225-229.

Dhingra D and Paul S. 2006. Drying kinetics of fluidized bed drying of garlic slices. Processing and Food Engineering Volume 87.

Dumulin DL and Lozada EP. 1982. The drying characteristic of coconut meat. Phillipine Society of Agricultural Eng. Journal of Agriculture Engineering. p16-22.

Ebewele RO and Jimoh AA. 1988. Feasibility study of kaduna state ginger processing industry. Ahmadu Bello University Chemical Engineering consultant. pp. 63-80.

Emehute JKU. 2002. Eds. Proceedings of Three Training Workshops on Ginger Production, Processing, Utilization and Marketing held at the NRCRI, Umudike. 59p.

Ernst E, Pittler MH. 2004. Randomized controlled trial of ginger to treat nausea and vomiting in pregnancy. Obstet. Gynecol. 103(4):639-645.

FAO. 1999. Production Year book. Food and Agriculture Organization. The United Nation. Rome. Italy. 53:449.

Farrell KT. 1999. Spices, Condiments, and Seasonings. 2nd Ed. Springer. New York.

Fellows PI. 1998. Food Processing Technology. Ellis Horwood Chichester. pp: 281-294.

Fellows. 1997. Guidelines for Small-Scale Fruit and Vegetable Processor s, FAO Agricultural Services Bulletin 127, FAO of United Nations, Rome.

Ferreres F, Gil MI and Tomas-Barberan FA. 1996. "Anthocyanins and flavonoids from shredded red onion and changes during storage in perforated films", Food Res. Int., 29, 389-395.

Flores AF. 1954. Anales fac farm.Y bioquim. Univ nacl. Mayor. Sen. Marcos (Lima, Peru), 2, 229-233.

FSIS, 2002. Survey for irradiated food harbs and spices, dietary supplements and prawns and shrimps. Food Survey Information Sheet, 25 (02): 1-61.

Furia RE. 1972. Hand book of Food Additives, 2nd Ed. The chemical Rubber Co. 18901. Cran Wood parkway, Cleveland, Ohio. 44128.

Furia TS. 1972. Antimicrobial Food Additives, Hand book of Food Additives, 2nd Ed. CRC press. USA. 142-143.

Gara EAO, Hill DJ and Maslin DJ. 2000. Activities of garlic oil, garlic powder and their daily constituents against Helicobacter pylori. Applied and Environmental Microbiology, 66 (5): 2269-2273.

Garcia P, Brenes M, Romero C & Garrido A. 1999. Color and texture of acidified ripe olives in pouches. Journal of Food Science 64: 218–251

Garg HP and Krishnan A. 1974. Solar drying of agricultural products, I. Drying of Chilies in a solar cabinet dryer. Annuals of Aridzone 13: 285292.

Gorjiae SH, Tavakkoli HT, Khoshtaghaza MH and Nikbakht AM. 2011. Drying kinetics and quality of barberry in a thin layer dryer. Journal of Agriculture Science and Technology. 13: 303-31.

Gould GW. 1989. Introduction. In: Mechanisms of Action of Food Preservation Procedures. Gould GW, Ed. Elsevier Applied Science, London. pp. 1–10.

Gould GW. 1995. Overview. In: New Methods of Food Preservation. Gould, G. W., Ed. Blackie Academic and Professional, Glasgow.

Govindarajan VS. 1982. Ginger-chemistry, technology and quality evaluation: Part 2. CRC Critical Reviews in Food Science and Nutrition 17:189–258.

Goyal M and Mathew S. 1990. Physico-chemical characteristics of cauliflower dried under different drying conditions, Indian Journal of Food Nutrition and Dietetic, 27(2): 39-46.

Gugnani HC and Ezenwanze ECJ. 1985. Commun Dis., 17: 233.

Henderson DE. 1992. Thermal decomposition of capsaicin, 1, Interactions with oleic acid at high temperatures. J.of Agricultural and Food Chemistry.40: 2263-2268.

Hong-Gyunghoon, Lee-Seungkoo, Moon-Won, Hang-GH, Lee- SK, Moon-W. 1997. Synthesis of allin and its quantitative determination in garlic. Journal of the Korean Society for Horticulture Science. 34:3,216-220. Korea.

Hong-Gyunghoon, Lee-seungkoo, Moon-Won, Hang-GH, Lee-SK, Moon-W. 1999. Effect of processing treatments on change in quality of the functional components in garlic *Allium sativum L.*

Howard LR, Smith RT, Wagner AB, Villalon B and Burnse EE. 1994. Provitamin A and ascorbic acid content of fresh pepper cultivars (*Capsicum annuum L.*) and processed jalapenos. J. Food Sci., 59(2): 362-365.

http://dx.doi.org/10.1016/S0260-8774 (96)00021-0.

Hwang JM and Chung KM. 1998. Investigation of distribution and quality of dried red pepper (*Capsicum annuum L.)* in Andong market. J. Korean Soc. Hort. Sci., 39(6): 702-706.

Isidoro L, Leijskens R, Smith PG. 1995. Color retention in red Chili powder as related to delayed harvest. Journal of the Science of Food and Agriculture. 68 (2): 167-174.

Jai-Kiv-WV, Ming-Sai-Liv, Shin-Bong-Zin. 1996. Effect of pickling on the volatile compounds of garlic bulbs; Food Science 23(4)483-489. Taiwan.

Jain D and Tiwari GN. 2003. Thermal aspects of open sun drying of various crops. Energy oxford, 28 (2): 37-54.

Jebson R Sand Youzhang HE. 1994. Studies on the drying behaviour of garlic and a novel technology to produce high quality garlic at a low cost. Food and Bioproducts Proc 72: 73-78.

Jiang L and Kubota K. 2004. Differences in the volatile components and their Odor characteristics of green and ripe fruits and dried pericarp of Japanese pepper (XanthoxylumpiperitumDC.)J.of Agricultural and Food Chemistry.52: 4197-4203.

Jost M. 1997. Use of garlic powder in the feed of rearing piglets. Revue Suisse-d Agriculture, 29 (1): 35-38.

Joy CM, George PP, Jose KP. 2001. Solar tunnel drying of red Chilies. Journal of Food Science and Technology .38. 213-216.

Kaur G, Bajaj KL and Jaiswal SP. 1980. Studies on variation in protein and mineral contents in dried red fruits of chili varieties. Indian Food Packer January–February, 34(1): 21-23.

Kaushal M, Kumar N and Vaidya D. 2014. Processing quality of ginger (Zingiber officinale) land races in Himachal Pradesh. International journal of Farm Sciences. 4(3): 110-116;

Keey RB. 1980. Theoretical foundations of drying technology. In Advances in Drying, 1, ed. A.S. Mujumdar. Hemisphere Publishing, NY.

Keramat Ali, Koketsu M, Taveira Magathaes M. 2001. Brazilian ginger, general aspects, essential oil cienciae Ticnoligiade Alimenton Brazil.

Keramat Ali, Koketsu M, Taveira Magathaes M. 2002. Brazilian ginger, general aspects, essential oil cienciae Ticnoligiade Alimenton Brazil.

Khatun. 2012. The processing of green Chili powder The Faculty of Agricultural Engineering and Technology, Bangladesh Agricultural University, Mymensingh.

Kim Hee, Gee-Dong Lee. 1996. Quality attributes of Quarri green peppers at different storage temperatures. Korean Journal of Food Science and Technology, 28 (2):220-225.

Kim HK, Jo KS, Kwon OY and Park MH. 1992. Effects of drying temperature and sulfiting on the qualities of dried garlic slices. J Korean Agric Chem Soc 35: 6-9.

Kim MH. 1998. Mass Tranfser Characteristic during osmotic dehydration of gingerand its effect on quality. FSTA Vol. 31 (1991) No. 6 Te 380.

Kim S, Lee KW, Park J, Lee HJ and Hwang IK. 2006. Effect of drying in antioxidant activity and changes of ascorbic acid and Color by different drying and storage in Korean red pepper (Capsicum annuumL.).International J. of Food Science and Technology.41: 90-95.

Krishnamurthy K and Natarajan CP. 1973. Color and its changes in chillies. Indian Food Packer, January–February, p.39-44.

Kubee R, Velisek J. 1996. Evaluation of culinary and Pharmaceutical garlic based Products; Potravinarske vedy 14 (6): 415-425; Czech Republic.

Kumar S, Kumar R, Singh J. 2006. Cayenne/American pepper. In: Peter KV ed., Handbook of Herbs and Spices, Woodhead Publishing, Cambridge, UK, pp. 299–312.

Kumar, AT, Sandeep, M and Bhotmange Madhukar, G. 2012. Effect of Pretreatments on Quality Attributes of Dried Green Chilli Powder, International Science Community Association, Journal Engineering.

Lauhadia AP and Kulkarni PR. 1978. Dehydration of green chillies (Capsicum frutescens). Journal of Food Science and Technology, 15, 139-142.

Lawson ID, Han G, Han P. 1995. Spectrophotometric method for quantitative determination of allicin and total garlic thiosulfinates. Analytical Biochemistry 225: 157-160.

Lee J, Jiang S, Levine N et al. 2000. Carotenoid supplementation reduces erythema in human skin after stimulated solar radiation exposure. Proc Soc Exp Biol Med.; 223:170-174.

Li Y, Xu Shi-ving. 2007. Preparation of Garlic Powder with high allicin content. Agricultural Sciences China 6: 890-898.

Lien HC, Sun WM, Chen YH, Kim H, Hasler W, Owyang C. 2003. Effects of ginger on motion sickness and gastric low wave dysrhythmias induced by circularvection. AmJPhysiol Gastrointest Liver Physiol. 284(3):G481–9. Epub 2003/02/11. doi:10.1152/ajpgi. 00164.2002PMID:12576305.

Lopez-Hernandez J, Oruna-Concha MJ, Simal-Lozano J, Vazquez–Blanco ME and Gonzalen Castro MJ. 1996. Chemical composition of padron peppers (Capsicum annuum L.) grown in Galicia (N.W Spain). Food Chem., 57(4) 557-559.

Madamba PS, Driscoll RH and Buckle KA. 1993. Moisture content determination of garlic by convection oven method. Asian F. J., 8(2): 81-83.

Madamba PS, Driscoll RH, Buckle KA. 1993. Bulk density, porosity and resistance to airflow of garlic slices Drying Technology 11:7, 1837-1854 A Australica.

Madamba PS. 1997. Optimisation of the drying process: an application to the drying of garlic. Drying Technol 15: 117136.

Malik MN, Fenko MD, Shiekh AM, Wisniewski HM. 1997. Isolation of a tocopherol (vitamin E) from garlic. Journal of Agricultural and Food Chemistry 45 (3) 817-819. N.

Malviya MK and Gupta RSR. 1985. Design and development of natural convection solar dryer. Energy in Agriculture. Indian Society of Agricultural Engineers. Haryana Agricultural University Hissar, 4.

Mandala LG, Anagnostaras EF, Oikonomou CK. 2005. Influence of osmotic dehydration conditions on apple air-drying kinetics and quality characteristics. Food Engineering 69: 307-316.

Mangraj S, Singh A, Samuel DVK and Singhal OP. 2001. Comparative performance evaluation of different drying methods for Chilis. Journal Science Technology 38: (3) 296- 299.

Marx WM, Teleni L, McCarthy AL, Vitetta L and Thomson D. 2013. Ginger (*Zingiber officinale*) and chemotherapy-induced nausea and vomiting: a systematic literature review. Nutrition Reviews. 71(4):245–54.doi:10. 1111/nure. 12016 PMID: 23550785.

Meghvansi MK, Siddiqui S, Khan H, Gupta VK, Vairale MG, Gogo HK, Singh L. 2010. Naga Chili: a potential source of capsaicinoids with broad-spectrum ethnopharmacological applications. Journal of Ethnopharmacology 132: 1–14.

Minquez M, Isable M and Hornero–Mendez Damaso. 1994. Comparative study of the effect of paprika processing on the carotenoids in peppers (Capsicum annuum L.) of the Bola and Agridulce varieties, J. Agric. Food Chem., 42: 1555-1560.

Mishra RN. 1972. Absorption and desorption isotherms for groundnut and Chilies. M.Tech Thesis Indian Institute of Technology Kharagpur.

Mngraj S, Singh A, Samual DVK and Singhal OP. 2001. Comparative Performance Evaluation of Different Drying Methods for Chilis. Journal of Food Science and Technology. 38. (3). P. 296-299.

Mohan S, Rajan SS and Unnikrishnan G. 2013. Marketing of Indian Spices as a challenge in India. Int J Bus ManagInv 2:26-31. www.ijbmi.org.

Mongpraneet S, Abe T, Tsurusaki T. 2002. Accelerated drying of Welsh onion by far infrared radiation under vacuum conditions. J Food Engg 55: 147-156.

Mujumdar. 2004. Dehydration of products of biological origin, Science Publishes, UK.

Nath A, Bidyut C, Deka AK, Paul JD and Misra LK. 2013. Effect of slice thickness and blanching time on different quality attributes of instant ginger candy. Journal of Food Science and Technology. 50(1): 197-202.

NRC, National Research Council, Recommended Dietary Allowances, National Academy Press, Washington, DC, USA, 1989.

Nuutila AM. 2003. Puupponen-Pimia R, Aarni M and Oksman-Caldentey KM, "Comparison of antioxidant activities of onion and garlic extracts by inhibition of lipid peroxidation and radical scavenging activity", Food Chem., 81, 485-493.

Nwaoha M, Elizabeth I, Okafor, Gabriel I, Apochi and Veronica O. 2013. Production of oleoresin from ginger (Zingiber officinale) peels and evaluation of its antimicrobial and antioxidative properties. African Journal of Microbiology Research. 7(42): 4981-4989.

Ojimelukwe P.C, Onweluzo J.C., and Okechukwu E., "Effects of infestation on the nutrient content and physiocochemical properties of two cowpea (Vigna unguiculata) varieties," Plant Foods for Human Nutrition, vol.53, no.4, pp.321–332,1999.

Okafor GI and Okafor JNC. 2007. Effects of pricking, sun-drying and sieving on ginger (Zingiber Officinale Roscoe) Color and powder. Nigerian Food Journal. 25(1): 155- 160.

Osuna–Garcia JA, Wall MM and Waddell CA. 1998. Endogenous levels of tocopherols and ascorbic acid during fruit ripening of new Mexican type chili (*Capsicum annuum L.*) cultivars. J. Agric. Food Chem., 46: 5093-5096.

Ozgoli G, Goli M. 2009. Effects of ginger capsules on pregnancy, nausea, and vomiting. J Altern Complement Med. 15(3):243-246.

Pardo JE, Escribano J, Gómez R and Alvarruiz A. 2007. Physical-chemical and sensory quality evaluation of garlic cultivars. Journal of Food Quality 30(5): 609–622.

Parquet C.1974. Standard Methods for the Analysis of Oils, Fatsand Derivatives, IUPAC, 6th edition.

Pecoraro A, Patel J, Guthrie T, Ndubisi B. 1998. Efficacy of ginger as an adjunctive anti-emetic in acute chemotherapy-induced nausea and vomiting. ASHP Midyear Clinical Meeting. 33:429.

Pereira AS and Stringheta PC. 1998. Considerations on turmeric culture and processing. Horticultural- Brasileira, 16 (2): 102-105.

Pezzutti A and Crapiste GH. 1997. Sorptional equilibrium and drying characteristics of garlic. Journal of Food Engineering 31: 113–123.

Phoungchandang S and Sertwasana. 2010. Spray-drying of ginger- juice and physicochemical properties of ginger powders. Science Asia. 36: 40-45.

Policegoudra RS and Aradhya SM. 2007. Biochemical changes and antioxidant activity of mango ginger (Curcuma amada Roxb.) rhizomes during postharvest storage at different temperatures. Postharvest Biology and Technology. 46:189-194

Portoni G, Chng LA, Karimi-Tabesh L, Koren G, Tan MP, Einarson A. 2003. Prospective comparative study of the safety and effectiveness of ginger for the treatment of nausea and vomiting in pregnancy. Am. J. Obstet. Gynecol. 189(5):1374-1377.

Powell LA. 1973. Garlic seasoning. U S Patent, 3:756-833.

Pruthi JS, Singh LJ, Kalbag SS and Girdharilal. 1959. The dehydrated of garlic powder, Food Science, (12): pages 444-448.

Pruthi JS. 1974. Improvements in or relating to the manufacture of garlic powder. Indian Patent, 134-964.

Pruthi JS. 1998. Spices and condiments. National Book Trust.-Fifth-Edition. PP-152. India.

Pruthi JS. 2001. Spices and condiments. National book Tryst. 5thED India. P.152. Pruthi. 2006. Processing and preservation of ginger, Journals of spices and Aromatic Crops. 1(1):1-19.

Rahman MJ, Talukder MAI, Rani L, Saha KC and Nahid MSI. 2013. The effect of processing techniques on the shelf life, nutitional and sensory quality of ginger (Zingiber officinale) powder and paste. Journal of Innovation and Development Strategy. 7(3): 6066.

Rahman MS. 2007. Purpose of food preservation and processing. In: Handbook of Food Preservation. Rahman, M. S., Ed. Marcel Dekker, New York. pp. 1–9.

Raina BL and Teotia MS. 1985. Evaluation of chilies (*Capsicum annuum L.*) grown in Jammu and Kashmir. Indian Food Packer, 39: 6-10.

Raina BL, Teotia MS, Pruthi JS, Kalra CL, Singh J and Nandpuri KS. 1988, Studies on the Evaluation of Some New Onion Cultivars for Their Suitability for Dehydration. Indian Food Packer, 42 (1) pp. 7-14.

Raina PU and Usha, RP. 1996. Studies on fruit weight and its related characters in chilli (Capsicum annuum L.). International Journal of Tropical Agriculture, 14(4): 123-130.

Rangana and Bajaj. 1966. Manual of Analysis of Fruits and Vegetables products. Tata Me. Grew-Hill Co. Ltd. New Delhi. 2-95, 635.

Ravindran PN, Johny AK and Nirmal Babu K. 2006. “Advances in Spices Research: History and Achievements of spices Research in India Since Independence, Agrobios, Jodhpur.

Rennie TJ, Vigneault C, Raghavan GSV and De Ell JR. 2001. Effects of pressure reduction rate on vacuum cooled lettuce quality during storage. Canadian Biosystems Engineering. Vol. 43(3): 39-43.

Richardson KC. 1966. Effect of dehydration temperature on quality of ginger. Food Technology. 18: 95.

Roby-HR, Araniti-EV, Herrera-Me, Guinle-VB, Winter-PL. 2000. Garlic fast drying. Revista-de-la-Faculted-de-Ciencias-Agrarias-Universidad-National-de-cyyo. 32:1.

Rodriguez DW. 1971. Commodity bulletin no.: 4 Agric. Planning unit, Ministry of Agric. And Fisheries, Jamaica.

Rosengarten Frederic. 1973. "The Book of Spices" Pyramid, New York.p.334.

Ruth S, Boscaini E, Mayr D, Pugh J and Posthumus M. 2003. Evaluation of three gas chromatography and two direct mass spectrometry techniques for aroma analysis of dried red bell peppers. International J. of Mass Spectrometry223: 55-65.

Santagapita P, Laghi L, Panarese V, Tylewicz U, Rocculi P and Dalla RM. 2013. Modification of transverse NMR relaxation time and water diffusion coefficients of kiwifruit pericarp tissue subjected to osmotic dehydration. Food and Bioprocess Technology. 6(6): 1434-1443.

Sasaki JI, Kita T, Ishita K, Uehisawa H and Matsue H. 1999. Antibacterial activity of garlic powder against Escherichia Coli 0-157. Journal of Nutritional Science and Vitaminology, 45 (6): 785-790.

Shams-Ud-DinM, Moinuddin M and Islam MF. 2001. Studies on the processing and preservation of Chili (Capsicum frutescens) paste. A project report, submitted to the Dept. of the Dept. of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh in partial fulfillment of the requirements for the B. Sc. Agril. Engg.

Shan C, Wang C, Liu J and Wu P. 2013. The analysis of volatile flavor components of Jin-Xiang garlic and Tai-An garlic. Agricultural sciences 4(12): 744– 748.

Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. 2nd edition. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi, India, pp.716.

Sharma GP and Prasad S. 2001. Drying of garlic (*Allium sativum*) cloves by microwave-hot air combination. Journal of Food Engineering. 50: 99-105.

Sharma GP, Prasad S. 2001. Drying of garlic (Allium sativum) cloves by microwave-hot air combination. Journal of Food Science 46: 410-413.

Shirin APR and Prakash. 2010. Chemical composition and antioxidant properties of ginger root (Zingiber officinale). Journal of Medicinal Plants Research. 4(24): 2674-267.

Singh A, Chauhan AK, Singh RP, Yadav P and Sebaeai AL MAQ. 2015. Development of Production Technology to Manufacture of Green Chilli Powder Proceeding - Kuala Lumpur International Agriculture, Forestry and Plantation, Hotel Putra, Kuala Lumpur, Malaysia. ISBN 978-967-11350-7-5,

Siviero P, Giorgi A and Giorgi-Ade. 2001. Technical marketing aspects of chili pepper. Informatiore–Agrario, 57: 45-48.

Sontakke BK and Roul PK. 2007. Integrated management of rhizome fly, Mimegralla coeruleifrons infesting ginger crop. Journal of Entomological Research, 31, 201–204.

Srivastava PK, Parikh MM, Sawani NG and Raman S. 1994. Effect of drip irrigation and mulching on tomato yield. Water Management. 25: 179-184.

Srivestava RP and Sanjeev K. 1994. Fruits and vegetable preservation (principle and practices), Appendices-V, p.381-382.

Starthy GA, and Nosova LL. 1982. Productivity and food quality of early capsicum cultivars. PavyshenieProdukhivisostiplodovykh-I, Ovoshchnykhkultur.74-79.

Stivala LA, Savio M, Cazzalini O. 1996. Effect of β-carotene on cell cycle progression of human fibroblasts. Oxford University Press. Carcinogenesis. 17(11):23952401.

Teotia MS and Raina BL. 1986 Evaluation of chilies grown in Himachal Pradesh, Indian Food Packer, 42: 11-14.

Thomson M, Corbin R, Leung L. 2014. Effects of ginger for nausea and vomiting in early pregnancy: ameta-analysis. Journal of the American Board of Family Medicine: JABFM.;27(1):115–22. Epub2014/ 01/07. doi:10.3122/jabfm. 2014.01.130167 PMID: 24390893.

Toontom N, Meenune M, Posri W and Lertsiri S. 2012. Effect of drying method on physical and chemical quality, hotness and volatile flavour charactristics of dried Chilli. International food research journal, 19 (3), 1023-1031.

Topno PN, Vinothini A, Jayaprakash SH, Varadaiah V, Sheshagiri SH, Srinivas PM and Naidu MM. 2001. Ginger–garlic paste in retort pouches and its quality. Journal of Food Process Engineering 66 (5): 1-8.

Topno PN, Vinothini A, Jayaprakash SH, Varadaiah V, Sheshagiri SH, Srinivas PM and Naidu MM. 2013. Ginger-garlic paste in retort pouches and its quality. Journal of Food Process Engineering, 36(1), 1–8. http://dx.doi.org/10.1111/jfpe.2013.36.issue-1

Tulasidas TN, Raghavan GSV and Mujumdar AS. 1995. Microwave Drying of Grapes in a Single Mode Cavity at 2450 MHz – II: Quality and Energy Aspects. Drying Technology. Vol.13 (9):1973-1992.

Verma RC and Gupta AK. 1996. Effect of pre-treatments on quality of open sun dried Aonla. International Agri. Engi. J., 5(1/2): 63-69.

Vutyavanich T, Kraisarin T, Ruangsri RA. 2001. Ginger for nausea and vomiting in pregnancy: randomized, double-masked, placebocontrolled trial. Obstet. Gynecol. 97:577-82.

Wang J. 2002. A single-layer model for far-infrared radiation drying of onion slices. Drying Technology 20: 1941-1953.

Wang Y, Xia Y, Wang J, Luo F and Huang Y. 2009. Capsaiciniods in chili pepper (Capsicum annuumL.) powder as affected by heating and storage methods. American Society of Agricultural Engineers.52: 20072010.

Waris Qidwai, Riaz-Qureshi, Hasan-SN, Azam. 2000. Effect of dietary garlic on the Blood pressure in humans a pilot study.

Weidner MS, Sigwart K. 2000. The safety of aging erextract in therat. Journal of Ethnopharmacology.; 73(3):513–20.PMID:11091007.

Williams PG. 2006. Health benefits of herbs and spices. Publ Health Med J Aust. 185:S17–8. http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1034&context=hbspapers.

Yamada Seiyaku Co. Ltd. 1973. Garlic powder. Japanese Patent, 4824737.

Yoo KS and Pike LM. 1998. "Determination of flavor precursor compound S-alk(en)yl-L-cysteine sulfoxides by an HPLC method and their distribution in Allium species", Sci. Hortic., 75, 110.

Yoontee C, Sang Bok L, Jitto J and Jae Don S. 1995. Effects of drying conditions ofginger and storage methods of ginger powder on the qualities. Agric. Engg.Abstracts 1996 Vol. 21 (4).

Appendix-A: Ginger, Garlic and Green Chili collection and processed

Ginger

Sliced Ginger

Garlic

Garlic Cloves

Green Chili `

Sliced Green Chili

Appendix-B: Analysis work carried out during research

Determination of pH

Determination of TSS

Determination of Physicochemical Parameter

Determination of Proximate Composition

Determination of Mineral Content

Appendix C: Different drying process (Sun dried, Cabinet dried, Shade dried)

Sun Dried Ginger

Sun Dried Green Chili

Cabinet Dried

Cabinet Dried

Shade Dried

Shade Dried

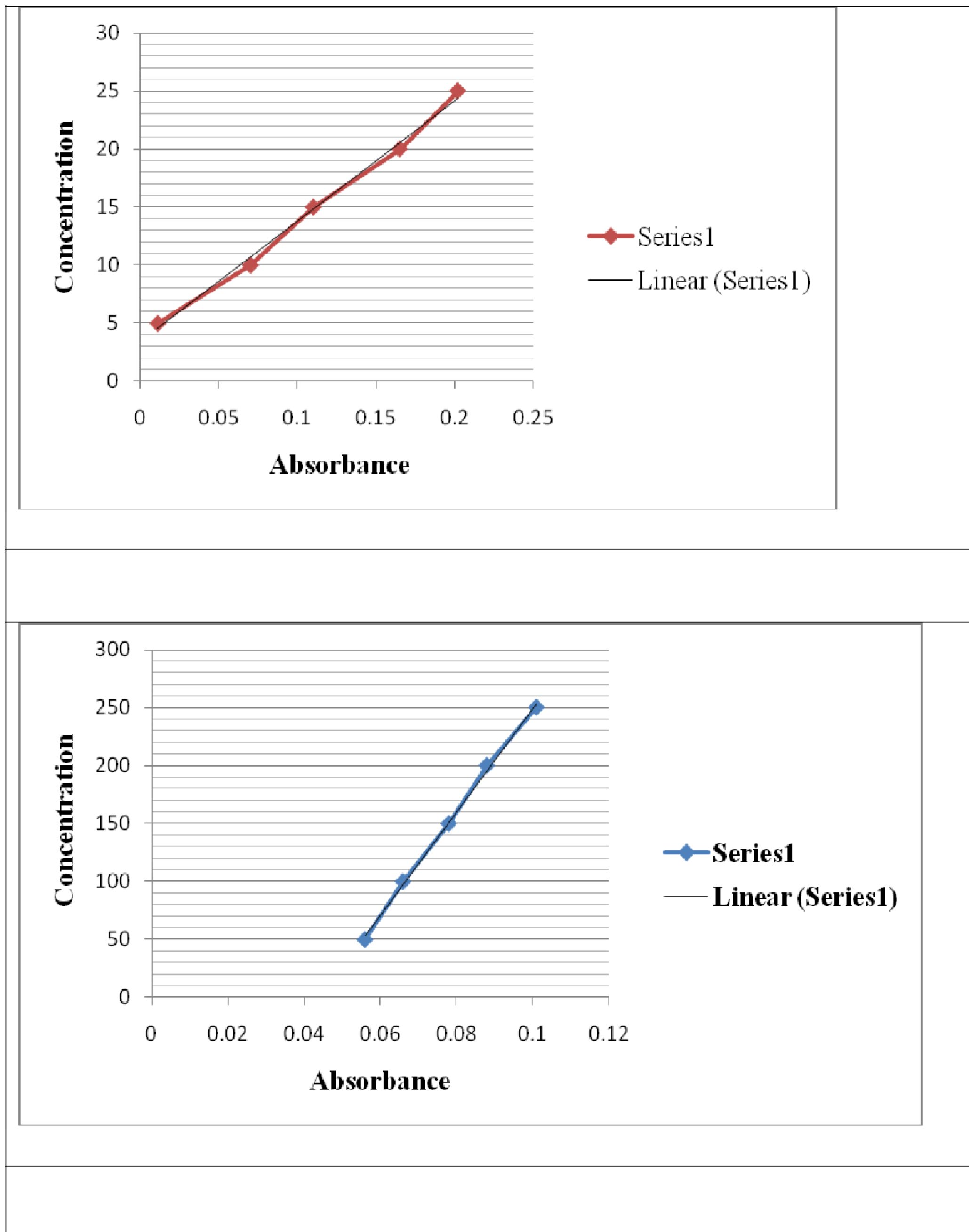
Appendix D: Powder and paste products

Ginger Powder and Paste

Garlic Powder and Paste

Green Chili Powder and Paste

Appendix E: Standard curve of vitamin C and β-Carotene



Appendix F: Hedonic Rating Test

Name: **Date:**

Taste this samples and check how much you like or dislike it. Use the appropriate scale to show your attitude by checking at the point that best describe your feelings about the sample, please give a reason for this attitude. **An honest expression of your personal feeling will help us.**

Hedonic	Samples	Attributes															
		Color				Flavor				Taste				Appearance			
		S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Like extremely																	
Like very much																	
Like moderately																	
Like slightly																	
Neither like nor dislike																	
Dislike slightly																	
Dislike moderately																	
Dislike very much																	
Dislike extremely																	

Extra comments on each sample if any

Biography

Sathi Das passed the Secondary School Certificate Examination in 2009 followed by Higher Secondary Certificate Examination in 2011. She obtained her B.Sc. (Hons.) in Food Science and Technology (BFST) from Faculty of Food Science and Technology, Chittagong Veterinary and Animal Sciences University (CVASU), Bangladesh. Now she is a candidate for the degree of MS in Food Processing and Engineering under the Department of Food Processing and Engineering of Faculty Food Science and Technology, CVASU. Her research interests are processing and preservation of spices by different preservative for the higher shelf life storage.