ISSN No:-2456-2165

# Upshot Outcome of *Cinnamomum Verum* Powder Relative to Hypertension

Alishbah Farrukh
The University of Faisalabad

**Abstract:- Economic burden and lifestyle habits have increased the prevalence of high blood pressure that can be detrimental. Hypertension is one of the major public health issues and is common in both genders. The medicinal plants and their antioxidant, antifungal and therapeutic properties have gained importance in recent years to fight lifestyle related health burdens such as CVDs, high blood pressure etc. *Cinnamomum verum (C. verum)* is one of the crude plant that is used for medicinal and therapeutic benefits worldwide. It is recognized as cinnamon and have benefits against inflammation, menstrual activity and bacterial stains. The current study was planned to analyze the mineral profile and chemical composition of *C.verum*and its proficience results towards blood pressure levels of both male and female belonging to the areas of Jinnah colony, Gulberg and Model town Faisalabad. Results showed that C. verum powder holds 5.3±0.12% of moisture content and 2.2±0.15% of ash. Crude fiber, crude protein, crude fat and nitrogen free extract (NFE) were found to be 31.02±0.6%, 3.3±0.15%, 3.8±0.2% and 54.38±0.7% respectively. 32 subjects, male and female adults above 30 years of age who are suffering from high blood pressure were selected randomly according to their history and current blood pressure levels. 16 participants are included in control group (8 males and 8 females) and 16 are in experimental treatment group (8 males and 8 females). Patients with hypertension were fed 1.5g cinnamon powder for 20 days in order to get to know the positive effect of cinnamon powder towards the amelioration of hypertension. Blood pressure levels of all subjects were measured before initiation of efficacy and after every 5 days of consumption. Diet of subjects was modified with no restriction of medicine intake. The data was introduced to statistical analysis and results were found significant for $G_{TF}$ and $G_{TM}$ ($P < 0.005$) at the 20$^{th}$ day of trial. Systolic blood pressure levels were from 131.25±8.34 to 118.75±6.40 mmHg and diastolic blood pressures were from 100±9.25 to 83.7±15.97 mmHg diastolic blood pressure in $G_{TF}$ and in $G_{TM}$ systolic blood pressure were from 127.5±4.62 to 125±5.34 mmHg but the diastolic pressure levels were measured to be 110±17.7 to 83.75±9.61 mmHg. High blood pressure levels were declined significantly.**

## I. INTRODUCTION

Globally, different regions of the world are experiencing changes from predominance of acute disorders to the supremacy of chronic diseases in adults that is termed to be the 'epidemiological transition'. Hypertension is prevailing in both genders and can be seen easily in overweight and obese women. The extent of hypertension is known to increase the number of deaths in hospitals. Prevalence of hypertension is more often in men than women. Among men, more occurrence of being hypertensive was in those who were richer than to those with low academic and occupational status. Hypertension was found to occur more in women with low socio-economic and education status (Minh *et al.,* 2006*).*

The major factor of CVD's includes hypertension, which is closely linked with 65%-78% of obesity (Mathieu *et al.,* 2009). In hypertensive patients, Renin-Angiotensin System (RAS) activation is supposed to have activity of insulin resistance. Other evidences have shown that pro-inflammatory cytokines, leptin and reactive oxygen species amounts have been increased with the increase in number of adipocytes (Furukawa S *et al.,* 2004).

Hypertension increases two-four-fold risk of morbidity and mortality. The hazard is proportional in elevating systolic and diastolic blood pressure levels at any age in either male or female. Smoking, obesity, stress and family history of hypertension are the risk factors of hypertension. Anxiety and depression are major predictors of later hypertension and prescription treatment of high blood pressure (Jonas *et al*., 2009).

Hypertension and heart disease are the two paramount cause of heart failure. High blood pressure is the condition that occurs when the pressure of blood is high and it leads to the narrowing of the arteries which hinders the oxygen rich blood flow towards heart (Rama Krishnan *et al.,* 2003). Recognition of the hypertensive heart patients is judgmental as these patients are more vulnerable to myocardial infarction, arrhythmias and sudden cardiac death (Diamond *et al*., 2005).

Treatments available for controlling hypertension involve the use of antihypertensive drugs. But despite the use of these agents, hypertension is uncontrolled worldwide (Weber *et al*., 1999).

ISSN No:-2456-2165

To cope up hypertension, crude plants have been used as medicine by the countries like Nepal and India. The use of plants and their products as medicines could be traced as far as the rise of civilization. The use of medicinal plants to treat the diverse trends of ailments such as diabetes, hyperlipidemia, cardiovascular disorders and hypertension has gained importance over the recent years in many countries (Bahmani *et al*., 2015). According to WHO 80% population belongs to rural areas utilize traditional herbal medicines for their primary health care so it has gained interest on the use of medicinal plant properties. These medicinal plants include *Xanthoxylumarmatum* (Timur), *Ocimum sanctum* (Tulsi), *Cinnamomumzeylanicum*(Dalchini) and *Origanummajorana*(Ram Tulsi) were found to have bactericidal effects against 10 medically recognized bacterial strains (Joshi *et al*., 2009).

Functional foods play role in human mental as well as physical health as these foods cure illnesses. Now-a-days people choose foods that give additional benefits to their health along with the nutritional significance and thus select functional food items. Vitamins, minerals, phytosterols, probiotics and antioxidants are included in list of functional foods (Broring*et al.*, 2010). *Functional foods* are defined by Academy of Nutrition and Dietetics as "enhanced, enriched and fortified unrefined foods that provides complementary constructive benefits to the consumers who take variety in diet on daily basis in adequate quantity" (Crowe KM and Francis C, 2013).

Functional foods are foods taken daily with usual meal depicts more benefits beyond its nutritional value and imparts positive outcomes in treating certain diseases according to Stein and Rodriguez-Cerezo, 2008. Food for Specified Health Uses (FOSHU) relates to the foods that hold constituents which have been officially approved to state that these foods exhibit psychological as well as physiological advantage to the consumers. Intention of taking FOSHU refers to improve health such as control blood pressure and blood cholesterol. Proper introduction of functional foods in Europe have been yet not defined (Ministry of Health, Labour and Welfare Japan, 2015).

Functional foods neutralize free radicals and protect human body from reactive oxidative species (ROS) and thus prevent from cancer (Kwaik*et al.*, 2001; Embuscado*et al.*, 2015; Omar *et al.*, 2007). The phytochemical active ingredients of cinnamon illustrate its antioxidant nature. In current decade, this herb is gaining fame because of its anti-cancerous agents. About 250 species of *Cinnamomum* are available with a exclusive phenotype and genotype (Tung *et al.*, 2008).

*Cinnamomumverum (C. verum)* is one of the commercially used spice belongs to family of Lauraceae (Table 1). Its old botanical name was *Cinnamomumzeylanicum (C. verum).* This is true cinnamon specie of Ceylon tree. It is native to Malbar coast of India and Sri-Lanka. The other species include *Cinnamomumaromaticum* (C. cassia), *Cinnamomumloreiroi* or Saigon cinnamon, *Cinnamomumburmannii* (Korintje). All these four are the species of Ceylon among up to hundred species and are commercially used as a spice and for medicinal plant (The Seasoning and Spice Association, 2010). The widely distributed specie in Africa is the *C. verum.* These spices have a productive effect on metabolic syndrome (Met.S) markers like insulin resistance and hypertension that leads to heart diseases (Thomas *et al*., 2012).

*Cinnamomumzeylanicum*and *Cinnamomumaromaticum* are the species that are native to tropical Asia and Sri-Lanka (Hamidpur*et al*., 2015) and non-native to African countries like Nigeria, Ghana, Uganda, Comoros, Sierra Leone, Tanzania, Madagascar, Mauritius and Seychelles (Orwa*et al*., 2009). To treat cancer and cardiovascular diseases the barks are commonly used in Cameroon as spices (Kuete*et al*., 2011; Nkanwen*et al.*, 2013).

The enduring bark of cinnamon can rise from 10 to 40 meters and found in SriLanka, West India and Southeast Asia. Volatile oils can be found in its peel that is useful in treating conditions like vomiting, common cold, erectile impairments and muscle spasms. 10 grams of cinnamon in ground form contains 0.4g protein, 8.06g of carbohydrate, 0.12g of fat and 103.4 kcal energy. A study conducted on 60 women to see the effectiveness of *C. verum* in enhancing Hb levels after menstruation has resulted in imparting positive benefits in lift up iron levels of females and so hemoglobin in them (Hassan N.H. 2017).

The phenolic compounds present in cinnamon depicts anti-tumor, anti-cancer, anti-inflammatory and anti-hypertriglyceridemia outcomes. These constituents can be extracted through distillation and solvent extraction. Microbial growth and oxidation in food can be inhibited by adding cinnamon to food (D. R. A. Muhammad and K. Dewettinck, 2017).

Cinnamic acid, cinnamate and cinnamaldehyde are the derivatives of cinnamon play a role of scavenging free radicals and exhibits anti-inflammatory response. Therefore, cinnamon is a versatile and multifaceted therapeutic shrub (Rao PV and Gan SH, 2014). Out of 115 foods being tested, cinnamon was analyzed to have potential features of anti-inflammation (Gunawardena *et al.*, 2015). Trans-cinnamaldehyde compound of cinnamon notify its role as neuroprotective and anti-bacterial agent (Zhang LQ *et al.*, 2015).

*C. verum* bark, powder, oil and leaf are part of vast spectrum of pharmaceutical, nutritional, neutraceutical, medicinal, food stuffs and cosmetic applications. These are also useful for flavoring the foods. According to investigation

it is composed of phenyl propanoids and monoterpenoids and (E) Cinnamaldehyde (Mallavarapu*et al*., 2007).

Methalonic extract of Cinnamomum verum leaf (CLE) was demonstrated for its antioxidant and free radical fighter capabilities in comparison to ascorbic acid, trolox, gallic acid and butylated hydroxyl anisole. CLE recorded to have peroxidation resisting ability with the use of linoleic acid emulsion system, exhibiting chelation of metal ion along with neutralizing hydroxyl ion radical (Mathew Sindhu and T. Emelia Abraham 2005).

Thermal stability of leaf essential oils that are eugenol free was investigated and the consequences represented that elevated temperatures affects content of trans-cinnamonaldehyde and after incubating the leaf at 100 degree Celsius for 8 hours its retension of Cin (RC) reduces to 17.4% as compared to oil holding eugenol have shown higher stability. By adding eugenol thermal stability of essential oil and Cin (0.62% and 2.60%) could be enhanced (Yeh HF *et al.*, 2013).

The cinnamon can be used directly or in the form of powder and oil. In variety of desserts and soups its powder form is used to enhance the flavor. The extracted form of cinnamon has been proved to have positive effects against number of health issues as it is an antioxidant and is useful to cure diarrhea, cold, flu and cough. Its antimicrobial activities make it a preferred preservative. It is effective against ulcer causing *Helicobacter pylori*, LDL-cholesterol levels, regulates high blood pressure, effective for menstrual pain, arthritis and inflammation. This study is to understand the pragmatic impacts of cinnamon powder towards hypertension (Maheshwari *et al*., 2013).

There are multiple ways of cinnamon consumption; one of the simple method is by using cinnamon freshly garnished on foods in form of powder. Pills of cinnamon oil are also available in markets in form of supplements. The only precautionary measure that needs to be focused is that capsules must be derived from fresh cinnamon instead of powder available in grocery stores. Large doses of coumarin can be toxic which is present in cinnamon powder present in grocery stores and can cause risk of liver or renal disorder. To refrain from any risk or emergency it is preferable to buy cinnamon stick derived from Ceylon plant (Brenda Barron, 2017).

| **Classification of *C. verum*** | |
|---|---|
| Kingdom | Plantae (Plants) |
| Subkingdom | Viridiplantae (Green plants) |
| Infrakingdom | Streptophyta (Land plants) |
| Superdivision | Embryophyta |
| Division | Tracheophyta (Vascular plants) |
| Subdivision | Spermatophytina (seed plants) |
| Class | Magnoliopsida |
| Superorder | Magnolianae |
| Order | Laurales |
| Family | Lauraceae (Laurels) |
| Genus | Cinnamomum (Cinnamon) |
| Species | C. verum |

Table 1:- Taxonomy Hierarchy of *C. verum*

| **Languages** | **Common Names** |
|---|---|
| Latin | Cinnamomum |
| Espernato | Cinamo |
| Filipino | Kanela |
| Somali | Qorfe |
| Turkish | Tarcin |
| Arabic | Qarfa |
| Persian | Daarchin |
| Chichewa | Sinamoni |
| Urdu | Daarchini |
| Uzbek | Dolchin |
| Dutch | Kaneel |
| French | Cannelle |
| German | Zimat |
| Irish | Caineal |
| Italian | Cannella |

Table 2:- Common Names for *C. verum*in Different Languages

## II. OBJECTIVES

Objectives of the current study are as follows;

- To evaluate the effectiveness of *Cinnamomum verum* powder in attenuation of hypertension
- To carry out compositional analysis of cinnamon

## III. MATERIALS AND METHODS

### *A. Area of Research*

Research was conducted in The University of Faisalabad department of Doctor of Nutrition and Dietetics. Analysis was performed in the post graduate laboratory of The University of Faisalabad (TUF).

### *B. Raw Material Procurement*

*Cinnamomum verum* is the scientific name of cinnamon and it was bought from the herbal shop located in clock tower, Faisalabad.

*C. Preparation of Cinnamon Powder*

Cinnamon bark stick was cleaned with water, washed and sun-dried and then it was subjected to electric blender in order to make fine powder. This powder was sieved through 4mm mesh to get very fine powder (Palthur*et al.,* 2014).

*D. Characterization of C. verumpow*

*C. verum* powder introduced with several assays mentioned as follows;

➢ *Proximate Analysis*

*C. verum* powder was analyzed for moisture, crude protein, crude fat and ash content according to the methods of AOAC (2003).

*a. Moisture Content*

Moisture of *C. verm* powder was accessed by drying the sample in oven at 100±5 degree of Celsius till the sample weight became constant according to AOAC (2003) methods.

Moisture calculated by using the following formula:

$$\text{Moisture \%} = \frac{\text{Weight of fresh sample (g)} - \text{Weight of dried sample (g)}}{\text{Weight of sample (g)}} \times 100$$

*b. Ash Content*

Ash content of *C. verum* powder was determined according to the method of AOAC (2003). Ash estimation was conducted by direct incineration of sample obtained in a crucible. The crucible was heating on oxidizing flame till it produced no fumes, then kindled in a muffle kiln at 600 degree of Celsius for 2-4 hours till grayish white residue was obtained. Ash percentage is calculated using following formula:

$$\text{Ash \%} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

*c. Crude Fiber*

Sample was taken and analyzed for crude fiber according to procedure defined by AOAC (2003). Sample was taken in a beaker and with the addition of 150 ml preheated $H_2SO_4$ solution and heated it for 30 minutes. Contents were filtered by giving 2-3 washing with distilled water. Residue was transferred again to beaker and heated with KOH solution for 30 minutes. Filtration with distilled water was done again to make it alkali free. Residue was transferred carefully to tarred crucible and dried in oven at 150 degree of Celsius for 1 hour until constant was obtained. Contents were heated on flame until the smoke ceased to come out of sample. Sample was placed in muffle furnace at 55 degree of Celsius for 3-4 hours until grey ash was obtained then sample placed in desiccator to cool down and weighted. The difference in weight is calculated as crude fiber using following formula:

$$\text{Crude Fiber \%} = \frac{\text{Weight of insoluble matter(g)} - \text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

*d. Crude Fat*

Crude fat estimation was conducted using soxhlet extraction apparatus according to AOAC (2003). 5g of *C. verum* powder sample was taken in separate thimbles and placed in an extraction tube of soxhlet kit after wrappimg in filter paper. The modification of temperature of heater was so that incessant drops of ethanol fell on the sample in extraction tube. Remainders were shifted to dry weighted china dish which then was placed in hot air oven for evaporation for ether 4-5 hours. This china dish was then placed to desiccators in order to cool down the temperature and then again weighted it. According to AOAC procedures, using ethanol as solvent in soxhlet apparatus, 5g sample was used for crude fat determination.

$$\text{Crude Fat \%} = \frac{\text{Weight of sample (g)} - \text{Weight of fat freesample (g)}}{\text{Weight of sample (g)}} \times 100$$

*e. Crude Protein*

Protein percentage was determined by Kjeldahl method as defined by AOAC method (2003). In the digestion tube 0.5-1.0g sample was digested with the aid of 10-15ml concentrated $H_2SO_4$ in presence of 8g digestion mixture ($CuSO_4$:$K_2SO_4$) (8:1).Flask swirled in order to mix all the contents thoroughly and placed on heater to start digestion till mixture become clear (blue-green in color). This requires 2 hours to complete. The digest was cooled and then transferred to 100ml volumetric flask and volume was made up to mark by adding distilled water. 10 ml of digest was introduced in distillation tube then 10 ml of 0.5 N NaOH was added gradually through the same mechanism. Ammonia released was collected as $NH_4OH$ in conical flask containing 20ml of 4% boric acid solution with few drops of modified methyl red indicator. The solution was titrated against standard 0.1 N HCl solution.

Crude protein was calculated according to following formula:

$$\text{Nitrogen \%} = \frac{\text{Vol. of 0.1 NH2SO4(ml)} \times \text{Vol. of dilution} \times 0.0014}{\text{Wt. of sample (g)} \times \text{Vol. of aliqout sample(ml)}} \times 100$$

$$\text{Crude Protein} = \text{Nitrogen (\%)} \times 6.25$$

*f. Nitrogen Free Extract*

The NFE is calculated by using following formula according to (Urakue*t al*., 2016)

NFE % = 100 – (% moisture + % crude fiber + %crude protein + % ash + % crude fat)

*E. Principle Guide for Human Scrutiny*

The bio-evaluation was performed to investigate the influence and effectiveness of cinnamon powder against hypertension. Subjects were selected randomly from the areas of Model Town, Gulberg and Jinnah Colony Faisalabad. Selection procedure was carried out on the basis of their anthropometric measurements, current blood pressure, medical history, lifestyle practices and medication. Subjects who were willing to participate signed the Consent agreement letter. Subjects from both genders were selected. 32 subjects were chosen. Participants were introduced with the cinnamon powder for 20 days and their blood pressure levels were measured before initiation of the trial and after every 5 days of consumption. Dose is mentioned in table below (Table 3)

First sampling was performed before trial and second readings were taken at $5^{th}$ day of trials, similarly $3^{rd}$ measurements were taken at $10^{th}$ day followed with $4^{th}$ sampling which took on $15^{th}$ day of efficacy and last $5^{th}$ readings were obtained at $20^{th}$ day of research trials.

*F. Inclusion Criteria for Volunteers*

- Hypertensive males and females of age above 30 years were chosen for the efficacy study and divided into control and experimental treated groups.
- Sampling was done before initiation of research efficacy and next was performed on every $5^{th}$ day of research trials. The inclusion criteria for volunteers are mentioned below (Table 4).

*G. Blood Pressure*

Blood pressure includes diastolic levels and systolic levels. For the estimation of blood pressure sphygmomanometer is used.

*H. Parameters Studied*

- Diastolic blood pressure levels of both males and females above 30 years
- Systolic blood pressure levels of both males and females above 30 years

➢ *Systolic Blood Pressure*

The pressure of vessels of heart when it pumps the blood is known as systolic blood pressure.

➢ *Diastolic Blood Pressure*

The pressure of vessels when the heart rests between the beats it is termed as diastolic blood pressure.

*I. Statistical Analysis*

Results will be presented as means with their standard errors. Complete Randomized Design was applied to find out the significance level. Statistical analysis of data was performed using three-way ANOVA and Tukey's HSD.

| **Groups** | **$G_{0M}$** | **$G_{0F}$** | **$G_{TM}$** | **$G_{TF}$** |
|---|---|---|---|---|
| | Eight diseased males above 30 years of age in control group | Eight diseased females above 30 years of age in control group | Eight diseased males above 30 years of age in treatment group consuming cinnamon powder | Eight diseased females above 30 years of age in Treatment group consuming cinnamon powder |
| **Treatments** | Not consuming 1.5g *C. Verum* powder | Not consuming 1.5g *C. Verum* powder | 1.5g *C. Verum* powder | 1.5g *C. Verum* Powder |

Table 3:- Human Study Plan

| **S/N** | **Inclusion Criteria** | |
|---|---|---|
| 1. | Gender | Males and Females |
| 2. | Age Group | Above 30 years |
| 3. | Blood Pressure Status | Hypertensive |

Table 4:- Inclusion Criteria for Volunteers

| S/N | General Guidelines for Volunteers |
|---|---|
| **1)** | Avoid eating foods from outside |
| **2)** | Drink atleast 8 glass of water per day |
| **3)** | Choose foods with less sodium and prepared food stuff with less or no salt |
| **4)** | Select whole and unrefined grains containing fiber instead of processed products |
| **5)** | Use vegetable oils instead of banaspati ghee |
| **6)** | Aim to do 30-150 minutes exercise or brisk walk |
| **7)** | Eat variety of foods but in moderation |
| **8)** | Avoid having pickles and canned vegetables |
| **9)** | Cut back on foods with added salts and sugars |
| **10)** | Try to use poached or boiled egg instead of fried egg |
| **11)** | Replace high caloric foods with healthy and nutritious fruits and vegetables |
| **12)** | Choose skim milk, yogurt for dairy consumption |
| **13)** | Cut on sugar syrup containing canned fruits or fizzy drinks |
| **14)** | Consume more vegetables but avoid having ready-made sauces |
| **15)** | Avoid salted nuts and dried fruits (Try not to have more than a fist of dried fruits) |
| **16)** | Butter, margarine should be avoided |
| **17)** | Use lean meat, skinless poultry and prepare these stuff without using saturated or trans fats |
| **18)** | No added salt (NAS) is preferable |

Table 5:- General Guidelines for Volunteers

## IV. RESULTS

The current study was conducted to investigate the therapeutic significance of *C. verum* powder against hypertensive individuals. Accordingly, dose of *C. verum* powder was tested in both genders with hypertension by applying statistical design. Current study was presented in comprehensive manner. Two portions of results are allocated for better comprehension i.e. characterization of *C. verum* powder and efficacy studies.

### *A. Part 1: Characterization of C. verum Powder*

*C. verum* bark after being sundried and grinded to fine powder subjected to proximate analysis in order to determine the nutrient composition of leaf powder. Methods to investigate each fraction of proximate analysis were followed according to those mentioned by AOAC (2003).

➢ *Results of C. verum Powder Characterization*

Proximate analysis has its own significant importance in deciding the quality of raw materials being used. *C. verum* powder was assessed for various quality attributes such as moisture, ash, crude fat, crude protein, crude fiber and nitrogen free extract (NFE). Complete components of proximate analysis are made of these six quality parameters.

Results are tabulated in Table 6 that shows *C. verum* powder contains 5.3±0.12% of moisture content and 2.2±0.15% of ash content. Crude fiber, crude protein, crude fat and nitrogen free extract (NFE) was calculated to be 31.02±0.6%, 3.3±0.15%, 3.8±0.2% and 54.38±0.7% respectively (Table 8).

| Proximate Parameters | Composition (%) |
|---|---|
| **Moisture** | 5.3±0.12% |
| **Ash** | 2.2±0.15% |
| **Crude Protein** | 3.3±0.15% |
| **Crude Fat** | 3.8±0.2% |
| **Crude Fiber** | 31.02±0.6% |
| **Nitrogen Free Extract (NFE)** | 54.38±0.7% |

Table 6:- Proximate Composition (%) *C. verum* Powder

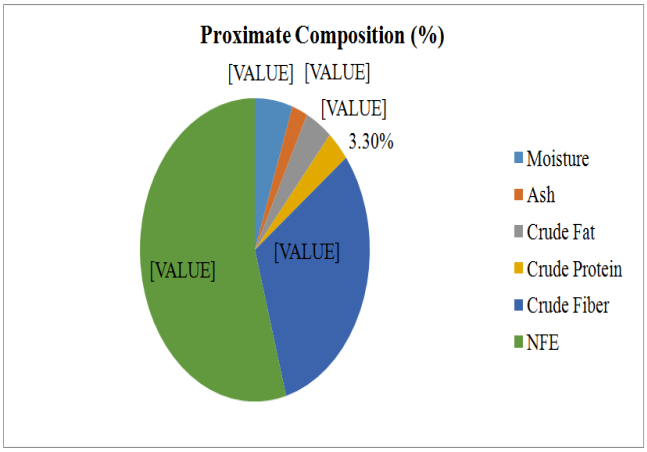


Fig 1:- Proximate Composition (%) *C. verum* Powder

| Minerals | Composition (mg/G) |
|---|---|
| **Iron** | 7.0 |
| **Zinc** | 2.6 |
| **Calcium** | 83.8 |
| **Chromium** | 0.4 |
| **Manganese** | 20.1 |
| **Magnesium** | 85.5 |
| **Sodium** | 0.0 |
| **Potassium** | 134.7 |
| **Phosphorous** | 42.4 |

Table 7:- Mineral Composition (%) *C. verum* Powder

| Parameters | Composition (g/100g) | |
|---|---|---|
| | **Sri Lankan Cinnamon** | **Chinese Cinnamon** |
| **Moisture** | 9.45±0.14 | 7.70±0.15 |
| **Ash** | 3.77±0.10 | 2.89±0.09 |
| **Crude Protein** | 4.99±0.10 | 4.10±0.09 |
| **Crude Fat** | 4.69±0.12 | 4.65±0.09 |
| **Crude Fiber** | 21.27±0.09 | 33.41±1.15 |
| **Nitrogen Free** | 55.83±0.90 | 47.25±1.24 |
| **Extract (NFE)** | 285.49±0.92 | 247.25±3.8 |
| **Energy Kcal/100g** | | 0 |

Table 8:- Proximate Composition of Sri Lankan and Chinese Cinnamon

| Minerals | Composition (mg/100g) | |
|---|---|---|
| | **Sri Lankan Cinnamon** | **Chinese Cinnamon** |
| **Iron** | 10.73±1.33 | 2.74±0.35 |
| **Zinc** | 0.33±0.05 | 0.35±0.04 |
| **Calcium** | 690.01±14.37 | 1157.36±12.38 |
| **Copper** | 0.65±0.006 | 0.41±0.05 |
| **Magnesium** | 60.71±1.83 | 74.89±8.88 |
| **Sodium** | 27.64±1.49 | 18.76±0.20 |
| **Potassium** | 381.67±4.73 | 197.00±9.32 |
| **Phosphorous** | 62.10±4.23 | 66.31±7.90 |

Table 9:- Mineral Composition Sri Lankan and Chinese Cinnamon

| Compounds | Percentage (%) | | | |
|---|---|---|---|---|
| | Fruit | Bark | Leaf | Root |
| **Pinene** | 2.19 | 3.34 | 0.73 | 5.70 |
| **Linalool** | 0.08 | 3.70 | 2.77 | 0.13 |
| **Limonene** | 1.0 | 1.2 | 0.3 | 6.2 |
| **Terpinolene** | 0.30 | 0.21 | 0.61 | 0.47 |
| **Cinnamaldehyde** | 0.3 | 50.5 | 2.7 | 0.1 |
| **Cinnamyl-acetate** | 0.10 | 8.78 | 1.00 | 0.12 |
| **Eugenol** | | | | |
| **Cymene** | 0.45 | 4.15 | 76.74 | 0.21 |
| **Cryophyllene** | 0.01 | 1.91 | 0.92 | 1.38 |
| **Sesquiterpenes** | 5.63 | 8.00 | 3.47 | 0.62 |
| **Monoterpenes** | 83.6 | 8.7 | 4.7 | 0.7 |
| **Phenyl propanoids** | 6.7 | 25.3 | 6.7 | 95.2 |
| | 0.9 | 64.8 | 85.4 | 2.2 |

Table 10:- Chemical Compounds *C. verum* Fruit, Bark, Leaf and Root Oils

*B. Part 2: Efficacy Study*

To investigate the ameliorative effects of *C. verum*, current study was conducted on human beings experiencing high blood pressure. Efficacy was conducted for 20 days and human subjects of both genders were selected. Participants were instructed to follow general guidelines. 32 subjects were selected and divided into 2 group's i-e. control group and treatment group. Each group comprised of 8 males and 8 females. Control group denoted with $G_{OF}$, $G_{OM}$ and treatment group indicated with $G_{TF}$ and $G_{TM}$. Participants allocated in treatment group were introduced with 1.5g/day *C. verum* (cinnamon) powder. Blood pressure levels of both groups' subjects were measured before initiation of trial, after 5, 10, 15 and 20 days of trial.

➢ *Results of Efficacy Study*

According to (Table 11), days affect the blood pressure levels significantly which can be clearly seen in hypertensive patients. The mean values for systolic blood pressure (Table 19) in treatment group $G_{TF}$ at 0 day was 131.25±8.34 mmHg which reduced to 127.5±7.07 mmHg at 5$^{th}$ day. Mean values were reduced further to 122.5±11.64 mmHg at 10$^{th}$ day and

at 15th day values were calculated to be 125±9.25 mmHg which decreased significantly up to 118.75±6.40 mmHg at 20th day. For the treatment group of males $G_{TM}$ systolic blood pressure mean at initiation was found 127.5±4.62 mmHg that was little descended to 126.5±7.44 mmHg at day 5th and came to be 125±5.34 mmHg at 10th day. Significant changes were observed at 15th day in systolic mean values that were 121.25±3.53 mmHg but it again increased to 125±5.34 mmHg at 20th day.

According to (Table 18), it explicated that mean value for diastolic blood pressure before initiation of trial in treatment group $G_{TF}$ was 100±9.25 mmHg that differentiated from mean value at 5th day calculated to be 107.5±7.071 mmHg. Momentous decline was observed at 10th day which indicated the mean value 98.75±25.319 mmHg and mean values reduced significantly at 15th and 20th which were 90±15.11 to 83.75±15.97 mmHg. In group $G_{TM}$ diastolic mean value before trial was 110±17.7 mmHg which was reduced to 106.25±7.44 mmHg at 5th day. The readings of 10th day mean values showed decline up to 100±14.14 mmHg which significantly reduced to 95±13.06 and 83.75±9.61 mmHg at 15th and 20th day respectively.

Comparison of control group with treatment group which was subjected to cinnamon powder showed 3.947 least significance difference of both systolic and diastolic blood pressures according to (Table 12). Least significance difference (LSD) test of both genders demonstrated significant results ($P < 0.05$).

| SOV | DF | Systolic Blood Pressure (MS) | Diastolic Blood Pressure (MS) |
|---|---|---|---|
| **Treatments ( T)** | 1 | 15405.6* | 11560.0* |
| **Day (D)** | 4 | 685.3* | 1070.9* |
| **Gender (G)** | 1 | 950.6* | 810.0* |
| **T × D** | 4 | 941.6* | 620.9* |
| **T× G** | 1 | 950.6* | 90.0$^{NS}$ |
| **D × G** | 4 | 39.7$^{NS}$ | 52.2$^{NS}$ |
| **T × D × G** | 4 | 114.7$^{NS}$ | 38.4$^{NS}$ |
| **Error** | 140 | 82.6 | 161.8 |
| **Total** | 159 | - | - |

Table 11:- Mean Squares for Systolic and Diastolic Blood Pressure of Participants Served with *C. verum* Powder
NS= Non-significant $P \geq 0.05$; * = Significant at $P< 0.05$
SOV= Source of Variance; DF= Degree of Freedom; MS= Mean Squares

| S/N | Treatment | Systolic Blood Pressure (mmHg) | Diastolic Blood Pressure (mmHg) |
|---|---|---|---|
| 1 | Cinnamon Powder | 125.00b | 97.50b |
| 2 | Control | 144.62a | 114.50a |
| **LSD** | | **3.947** | **3.947** |

Table 12:- Least Significant Difference of Systolic and Diastolic Blood Pressure Levels According to Treatment
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P \leq 0.05$).

| S/N | Day | Systolic Blood Pressure (mmHg) | Diastolic Blood Pressure (mmHg) |
|---|---|---|---|
| 1 | 0 | 133.13ab | 109.06a |
| 2 | 5 | 135.31a | 110.63a |
| 3 | 10 | 139.06a | 108.75a |
| 4 | 15 | 138.75a | 105.31a |
| 5 | 20 | 127.81b | 96.25b |
| **LSD** | | **6.1958** | **8.6717** |

Table 13:- Least Significant Difference in Systolic and Diastolic Blood Pressures
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P \leq 0.05$).

| S/N | Gender | Systolic Blood Pressure (mmHg) | Diastolic Blood Pressure (mmHg) |
|---|---|---|---|
| 1 | Males | 137.25a | 108.25a |
| 2 | Females | 132.38b | 103.75b |
| **LSD** | | **2.8163** | **3.9417** |

Table 14:- Least Significant Difference of Systolic and Diastolic Blood Pressure Levels in Males and Females
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P \leq 0.05$).

| | | Systolic Blood Pressure (mmHg) | | | | |
|---|---|---|---|---|---|---|
| **S/N** | **Treatments** | **Study Period** | | | | |
| | | **$D_0$** | **$D_5$** | **$D_{10}$** | **$D_{15}$** | **$D_{20}$** |
| 1 | Cinnamon Powder | 129.37cde | 126.87cde | 123.75de | 123.13e | 121.88e |
| 2 | Control | 136.88bc | 143.75b | 154.37a | 154.37a | 133.75bcd |
| **LSD** | | **10.155** | | | | |

Table 15:- Least Significant Difference of Systolic Blood Pressure Comparison in Control and Treatment Groups
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P \leq 0.05$).

| | | Diastolic Blood Pressure (mmHg) | | | | |
|---|---|---|---|---|---|---|
| **S/N** | **Treatments** | **Study Period** | | | | |
| | | **$D_0$** | **$D_5$** | **$D_{10}$** | **$D_{15}$** | **$D_{20}$** |
| 1 | Cinnamon Powder | 105abc | 106.86ab | 99.38bc | 92.50cd | 83.75d |
| 2 | Control | 113.13ab | 114.38a | 118.13a | 118.13a | 108.75ab |
| **LSD** | | **14.212** | | | | |

Table 16:- Least Significant Difference of Diastolic Blood Pressure Comparison in Control and Treatment Groups
Mean values in a column sharing similar letters do not differ significantly as determined by the LSD test ($P \leq 0.05$).

| Groups | Study Period | | | | |
|---|---|---|---|---|---|
| | **Initial (0 day)** | **Day 5** | **Day 10** | **Day 15** | **Day 20** |
| **$G_{0F}$** | 128.75±9.91 | 137.5±15.81 | 151.25±9.91 | 151.25±9.91 | 130±7.55 |
| **$G_{TF}$** | 131.25±8.34 | 127.5±7.07 | 122.5±11.64 | 125±9.25 | 118.75±6.40 |
| **$G_{0M}$** | 145±13.09 | 150±11.95 | 157.5±8.86 | 157.5±8.86 | 137.5±7.071 |
| **$G_{TM}$** | 127.5±4.62 | 126.25±7.44 | 125±5.34 | 121.25±3.53 | 125±5.34 |

Table 17:- Mean±SDSystolic Blood Pressure in Subjects

| **Groups** | **Study Period** | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | **Initial (0 day)** | **Day 5** | **Day 10** | **Day 15** | **Day 20** |
| **$G_{0F}$** | 110±11.952 | 112.5±7.071 | 115±5.345 | 115±5.34 | 105±9.258 |
| **$G_{TF}$** | 100±9.25 | 107.5±7.071 | 98.75±25.319 | 90±15.118 | 83.75±15.97 |
| **$G_{0M}$** | 116.25±16.8 | 116.25±14.07 | 121.25±11.25 | 121.25±11.25 | 112.5±8.86 |
| **$G_{TM}$** | 110±17.7 | 106.25±7.44 | 100±14.14 | 95±13.09 | 83.75±9.61 |

Table 18:- Mean±SD Diastolic Blood Pressure in Subjects

ISSN No:-2456-2165

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| trt | 1 | 11560.0 | 11560.0 | 71.45 | 0.0000 |
| day | 4 | 4283.8 | 1070.9 | 6.62 | 0.0001 |
| gender | 1 | 810.0 | 810.0 | 5.01 | 0.0268 |
| trt*day | 4 | 2483.8 | 620.9 | 3.84 | 0.0054 |
| trt*gender | 1 | 90.0 | 90.0 | 0.56 | 0.4570 |
| day*gender | 4 | 208.8 | 52.2 | 0.32 | 0.8625 |
| trt*day*gender | 4 | 153.8 | 38.4 | 0.24 | 0.9167 |
| Error | 140 | | 22650.0 | 161.8 | |
| Total | 159 | | 42240.0 | | |
| Grand Mean 106.00 | | | CV 12.00 | | |

Table 19:- Analysis of Variance Table for diastolic

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| trt | 1 | 15405.6 | 15405.6 | 186.53 | 0.0000 |
| day | 4 | 2741.2 | 685.3 | 8.30 | 0.0000 |
| gender | 1 | 950.6 | 950.6 | 11.51 | 0.0009 |
| trt*day | 4 | 3766.3 | 941.6 | 11.40 | 0.0000 |
| trt*gender | 1 | 950.6 | 950.6 | 11.51 | 0.0009 |
| day*gender | 4 | 158.8 | 39.7 | 0.48 | 0.7500 |
| trt*day*gender | 4 | 458.8 | 114.7 | 1.39 | 0.2410 |
| Error | 140 | | 11562.5 | 82.6 | |
| Total | 159 | | 35994.4 | | |
| Grand Mean 134.81 | | | CV 6.74 | | |

Table 20:- Analysis of Variance Table for systolic

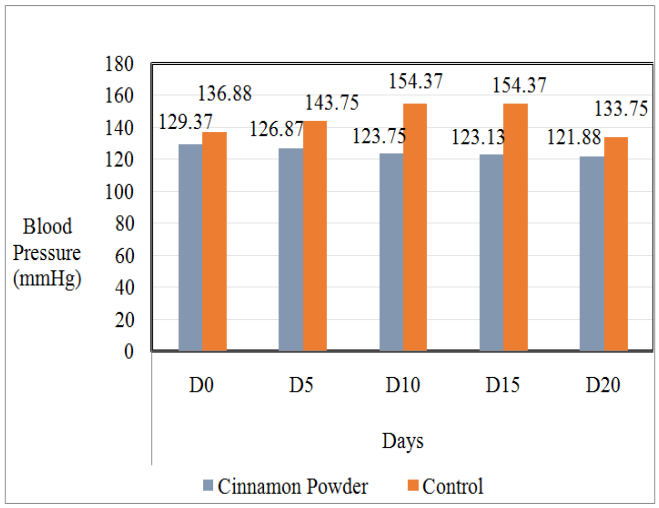


Fig 2:- LSD for Systolic Blood Pressure Levels

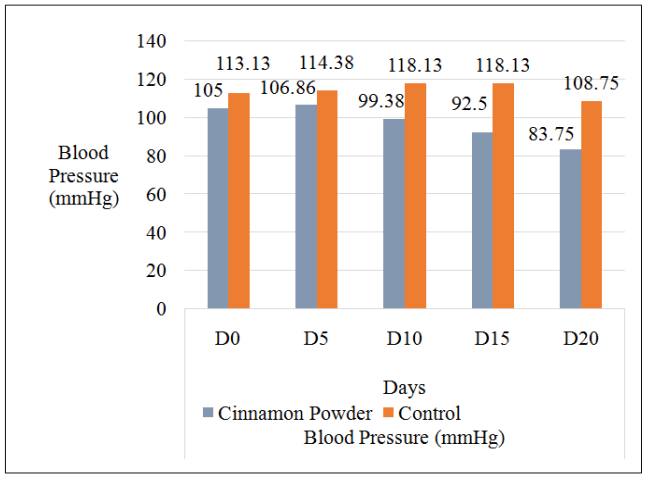


Fig 3:- LSD for Diastolic Blood Pressure Levels

## V. DISCUSSION

*C. verum* powder as medicinal herb has been used since ancient times as it aids in improving health issues and ailments such as disorders of respiratory system, digestive system, reproductive system illnesses, cough, flue and joint pains. Relieve from indigestion, toothaches and as a mouthwash remedy. Cinnamon is helpful for weak digestion, muscle pain, arthritis and rheumatism. It also acts as coagulant to stop bleeding (Hossein N *et al.,* 2013).

The current research findings of proximate analysis were in nearby values termed in literature. Possible variations are because of climate changes, origin, environmental conditions and area of analysis. One contributing factor is the genetic makeup of the material that indicates any variation.

The composition of cinnamon has been reported around the globe. Many researchers penned down the constituents in detail. Values for moisture, ash, crude fat, crude fiber and crude protein are 5.1%, 2.4%, 4%, 33.0%, 3.5% and nitrogen free extract (NFE) i-e carbohydrates are 52% respectively. The energy calculated to be 258 kcal/100g. These values are slightly varies from my analysis. The mineral profile of cinnamon includes iron, zinc, manganese, calcium, phosphorous, potassium, chromium and magnesium (Table 9). Study revealed that cinnamon holds 7.0mg/g iron (Fe), 2.6mg/g zinc (Zn), 83.8 mg/g calcium (Ca), 0.4mg/g chromium (Cr), 20.1mg/g manganese (Mn) and 85.5mg/g magnesium. Studies demonstrated that cinnamon contains 0.0mg/g sodium (Na), 134.7mg/g potassium (K) and 42.4mg/g phosphorous (P) electrolytes (Gul *et al.,* 2009). Minerals content reported in other research papers depicted that cinnamon composed of highest amount of potassium and lowest quantity of sodium. The moisture and fat content was found to be lower than revealed in other studies but energy values were lower than other studies however; ash, crude fiber and NFE values are near to the values presented by (Farhat *et al.,* 2001; Hussain *et al.,* 1985).

In a research study composition of per 100g of Chinese cinnamon was compared with Sri Lankan cinnamon (Table 10). The Sri Lankan cinnamon reported to have higher significance ($P<0.05$) compared to Chinese cinnamon. Carbohydrate and protein profile of Sri Lankan cinnamon was higher so the total energy content of Sri Lankan cinnamon was greater than Chinese cinnamon. Crude fiber content was found significantly higher ($P<0.05$) in Chinese cinnamon than in Sri Lankan cinnamon. In Sri Lankan cinnamon, fat content was investigated with no differences with the opposition sample significantly. These results were comparable with the proximate composition of *cinnamomum verum* to the Unites States of Agriculture, 2006. Mineral profile of Sri Lankan and Chinese cinnamon has been demonstrated in (Table 9). Calcium content was found to be highest in both cinnamon samples following sodium, potassium, magnesium and phosphorous. There were no significant variations of zinc found in Chinese cinnamon and Sri Lankan cinnamon (Ahmad *et al.,* 2007).

Fruit oil of cinnamon constitutes 7.7% cadinol, 5.6% cryophyllene and 36.0% cadinene. Sesquiterpenes are present in cinnamon fruit oil in 84% composition whereas, less than 9% of this group of compounds present in other parts of plant.

Table 10 highlights the percentage abundance of various components of different parts of cinnamon plant indicating the yield. Percentage value of cinnamon fruit oil was reported different from cinnamon leaf, bark and root oils. Composition of cinnamaldehyde and eugenol was not present in higher concentrations in oils which are the major constituents of plant organs. Specific intense aroma of cinnamon is due to the presence of sesquiterpenes. These are major compounds of oil also include monoterpenes and phenyl propanoids (P.A. Paranagama*et al.,* 2002).

Previous studies demonstrated the effect of aqueous extract of cinnamon towards high blood pressure. The methalonic extract in dose of 5, 10 and 20 mg/kg body weight administered directly into vein in rats with acute arterial hypertension. Wistar rats subjected to 20 mg/kg showed sustained arterial hypertension results for more than half and hour with means of 160.33±3.82 mmHg with significant results ($P < 0.05$). Rats received lowest dose of 5 mg/kg were observed to decrease the rising levels by 46.4±10.6 mmHg. Animals administered with 10 and 20 mg/kg were found to drop suddenly from 159.46±5.77 to 55.46±7.31 mmHg and from 176.66±6.86 mmHg to 83.46±16.03 mmHg resulted in quick decline of 68.9±4.8% and 50.7±9.5% (Nyadjeu*et al.,* 2013).

Abnormal renal excretory system has been known to be major developing cause of hypertension. Factors which contribute in declining the renal system function could disturb the balance of sodium and water leading to accelerate the arterial pressure. Renal Nerve Sympathetic nerve activity (RSNA) factor is responsible to disrupt and decline the renal excretory activity. Increase of sustained blood pressure from 18 mmHg in arterial pressure is because of decrease in RSNA up to 56 and 50% with angiotensin-II at on 2$^{nd}$ and 7$^{th}$ day of infusion (Dibona, 2003).

Meta-analyses in the past have been done to investigate the action of antiobesity drugs against alterations in hypertension. Changes in diastolic blood pressure levels and systolic blood pressure levels were interrogated. Blood pressure means for the subjects who were examined for three orlistat and three subutramine studies on overweight and type 2 diabetic subjects. Systolic blood pressure baseline range from 119 to 153 mmHg and diastolic blood pressure mean from 69 to 98 mmHg. Thus the overall variations in orlistat were found to be -1.9 (95% CI; -2.7, -1.1) mmHg and 0.5 (-1.1, 2.1) mmHg for subutramine for the systolic blood

pressure and for diastolic blood pressure change of placebo-controlled values measured to be -1.5 (-2.2, -0.8) and 1.7 (0.7, 2.6). Non-significant results were found in patients without diabetes along with minor reductions in systolic and diastolic blood pressures (K. Johansson *et al.,* 2009).

Reduction in hypertension also decrease the cadiovascular risk and ultimately decline the microvascular events thus decreasing the visual acuity as well as the functional impairments (Vijan*et al.,* 2003). Several factors such as anxiety, obesity and depression are contributors towards high blood pressure and stroke. Diet and exercise have worth significance in the hypertension and weight reduction that aids in CVD prevention (Jakacic*et al.,* 2001; Mathiew*et al.,* 2009).

The present study depicted that 1.5g cinnamon powder manifested positive results. Intake of cinnamon powder for 20 days resulted in significant results in both males and females. Systolic blood pressure levels have been decreased to 125 mmHg in cinnamon consuming group compared to 144.62 mmHg of control group. Diastolic levels of cinnamon group found to be 97 mmHg versus to 114 mmHg in control group. Results of current study demonstrated significant conclusions ($p < 0.05$). There are 95% chances that this study shows significantly similar positive results if it will perform 100 times. Therefore, cinnamon have an antihypertensive potential and it also found beneficial as per previous studies that its mixture along with ginger extract and enrichment of barley powder with it combat hypertension, hepatotoxicity and cardiotoxicity (Ihab K. Mohamed *et al.,* 2017).

## VI. SUMMARY

The purpose of this research is to determine the positive effects of *C. verum* towards high blood pressure levels in both males and females of age above 30 years and to conduct compositional assessment of *C. verum.*

*C. verum* is the natural herb also known as cinnamon, it holds therapeutic activities. It has been found to improve the patient systolic and diastolic blood pressure levels, thus helpful to reduce the risk of cardiovascular diseases. High blood pressure levels indicate the increased risk for heart attack and stroke. High BP levels lead to increase pressure of blood on the arteries which results in narrowing of arteries that obstruct the flow of oxygen rich blood. *C. verum* powder found to have positive manifestations against hypertension.

Cinnamon powder contains phenolic bioactive ingredients that are helpful to cure various diseases such as cinnamaldehyde and citral have been testified to impart free radical scavenging capabilities.

*C. verum* extract and volatile oils are used in cosmetics, beverages, detergents and for fortification and enrichment of food products. Cinnamon has gained popularity in treating headache, nausea, hay fever, cough, toothache, throat infection, gastrointestinal issues, ulcer, respiratory problems and polycystic ovary syndrome. Extracts of *C. verum* containing polyphenols and cinnamaldehyde devote medicinal properties and help reducing inflammation and cancerous cells growth.

This research study was conducted in institute of doctor of dietetics and nutritional sciences and compositional analysis was performed in the post-graduate laboratory at The University of Faisalabad, TUF.

Fresh *C. verum* bark was taken and cleaned properly which was then subjected to sun drying followed by grinding into fine powder. This powder was then sieved and assessed for proximate analysis. Results indicated that it contains moisture, ash, crude fiber, crude protein, crude fat and nitrogen free extract (NFE) 5.3%, 2.2%, 31.02%, 3.3%, 3.8% and 54.38% respectively.

Bioevaluation mode of testing was used to scrutinize the health promoting significance of cinnamon powder relative to hypertension. Hypertensive males and females of age above 30 years were selected. 16 hypertensive males and females were in control group (8 males in $G_{OM}$ and 88 females in $G_{OF)}$ contrary to 16 hypertensive males and females in treatment group (8 males in $G_{TM}$ and 8 females in $G_{TF}$). Control group participants were not introduced with any dose however; treatment group was subjected to 1.5g cinnamon for 20 days. Blood pressure levels were recorded before initiation of trial and after every 5 days of efficacy.

Results revealed that high blood pressure levels in both genders from day $5^{th}$ to $20^{th}$ day have been reduced. In treatment group of females ($G_{TF}$), diastolic levels reduced from 107.5±7.071 to 83.75±15.97 mmHg and systolic levels reduced from 127.5±7.07 to 118.75±6.40 mmHg. In treated group of males ($G_{TM)}$ diastolic levels were reported to decrease from 106.23±7.44 to 83.75±9.61 mmHg and systolic levels decline from 126.25±7.44 to 125±5.34 mmHg. The results lead to conclusion that *C. verum* is a good source of reducing hypertension in both genders and thus aids in reducing the risk of ailments due to high blood pressure.

## VII. CONCLUSION

- *C. verum* stick was dried under the sun after proper washing and cleaning of the bark in order to get fine powder
- Compositional analysis indicted that *C. verum* contains moisture, crude protein, ash, crude fat, crude fiber and nitrogen free extract (NFE) 5.3%, 3.3%, 2.2%, 3.8%, 31.02% and 54.38% respectively.
- The results of this research study concluded that *C. verum* powder depicts proficiency in amelioration towards high blood pressure.

## RECOMMENDATIONS

- Use of *C. verum* for a month on empty stomach and should be experimented on adults above 20 years of age with hypertension along with other parameters of weight and blood sugar levels
- Addition of *C. verum* extracts in foods should be encouraged to enhance enrichment with bioactive ingredients
- Nutrition education program should be conducted to increase awareness regarding nutrition and explore the use of functional compounds

## REFERENCES

[1]. A.T. Mbaveng, V. Kuete, in Medicinal Spices and Vegetables from Africa, 2017
[2]. Am J Obstet Gynecol. 2014 Nov;211(5):487.e1-6. doi: 10.1016/j.ajog.2014.05.009. Epub 2014 May 9.
[3]. AOAC., 2003. Official Methods of Analysis of the Association of Official's Analytical Chemists. 17th Edn., Association of Official Analytical Chemists, Arlington, Virginia.
[4]. Alu'datt, M. H.; Rababah, T.; Alhamad, M. N.; Gammoh, S.; Ereifej, K.; Johargy, A.; Kubow, S.; Almajwal, A. M.; Rawashdeh, M. Optimization of Phenolic Content, Antioxidant, and Inhibitory Activities of α-Glucosidase and Angiotensin Converting (AC) Enzymes from ZingiberOfficinale Z. International Journal of Food Properties 2016, 19(6), 1303–1316.
[5]. Ariaee-Nasab, N.; Vahedi, Z.; Vahedi, F. Inhibitory Effects of Cinnamon-Water Extract on Human Tumor Cell Lines. Asian Pacific Journal of Tropical Disease 2014, 4, S975–S978.
[6]. Albak, F.; Tekin, A. R. Effect of Cinnamon Powder Addition during Conching on the Flavor of Dark Chocolate Mass. Journal of Food Science and Technology 2015, 52(4), 1960–1970.
[7]. A comparison of essential oil constituents of bark, leaf, root and fruit of cinnamon (Cinnamomumzeylanicum Blum) grown in Sri LankaArticle (PDF Available) in Journal of the National Science Foundation of Sri Lanka 29(3-4):147-153 · January 2001 with 457 Reads DOI: 10.4038/jnsfsr.v29i3-4.2613.
[8]. Bröring, S.;. Innovation Strategies for Functional Foods and Supplements. Challenges of the Positioning between Foods and Drugs. Food Science and Technology (IFST), Sheffield 2010, 7(8), 111–123.
[9]. Baker WL, Gutierrez-Williams G, White CM, Kluger J, Coleman C. Effect of cinnamon on glucose control and lipid parameters. Diabetes Care. 2008;31:41-43.
[10]. Bruce S. Jonas, PhD; Peter Franks, MD; Deborah D. Ingram, PhD
[11]. Blood Pressure as a Cardiovascular Risk FactorPrevention and Treatment William B. Kannel, MD JAMA. 1996;275(20):1571-1576. doi:10.1001/jama.1996.03530440051036
[12]. Bigliardi, B.; Galati, F. Innovation Trends in the Food Industry: The Case of Functional Foods. Trends in Food Science & Technology 2013, 31(2), 118–129.
[13]. Brahm, A.; Hegele, R. A. Hypertriglyceridemia. Nutrients 2013, 5(3), 981–1001.
[14]. Burns E. What to Do With Cinnamon Sticks? https:// www.leaf.tv/articles/what-to-do-with-cinnamon-sticks/. Published 2016.
[15]. Crowe, K. M.; Francis, C. Position of the Academy of Nutrition and Dietetics: Functional Foods. Journal of the Academy of Nutrition and Dietetics 2013, 113(8), 1096–1103.
[16]. Cinnamon and its derivatives as potential ingredient in functional food—A review Dimas RahadianAjiMuhammada,b and Koen Dewettincka a Laboratory of Food Technology and Engineering, Faculty of Bioscience-Engineering, Ghent University, Gent, Belgium; b Department of Food Science and Technology, SebelasMaret University, Surakarta, Indonesia. INTERNATIONAL JOURNAL OF FOOD PROPERTIES 2017, VOL. 20, NO. S2, S2237–S2263 https://doi.org/10.1080/10942912.2017.1369102
[17]. English Language Teaching; Vol. 9, No. 6; 2016 ISSN 1916-4742 E-ISSN 1916-4750 Published by Canadian Center of Science and Education
[18]. Elliott, S.; Brimacombe, J. The Medicinal Plants of GunungLeuser National Park, Indonesia. Journal of Ethnopharmacology 1987, 19(3), 285–317.
[19]. Embuscado, M. E.;. Spices and Herbs: Natural Sources of Antioxidants–A Mini Review. Journal of Functional Foods 2015, 18, 811–819.
[20]. Efficacy & development of products by incorporating cinnamon for weight loss and diabetes
[21]. Eur J Nutr. 2016 Apr;55(3):1123-31. doi: 10.1007/s00394-015-0926-x. Epub 2015 May 19.
[22]. Evid Based Complement Alternat Med. 2014;2014:642942. doi: 10.1155/2014/642942. Epub 2014 Apr 10. Cinnamon: a multifaceted medicinal plant. Rao PV1, Gan SH2. PMID: 24817901 PMCID: PMC4003790
[23]. Esterbauer, H.;. Cytotoxicity and Genotoxicity of Lipid-Oxidation Products. The American Journal of Clinical Nutrition 1993, 57(5), 779S–785S
[24]. FFNR 5 | Volume 1|Issue 1|2014
[25]. Food and Nutrition Sciences, 2015, 6, 703-711 Published Online May 2015 in SciRes. http://www.scirp.org/journal/fnshttp://dx.doi.org/10.4236/fns.2015.68073
[26]. Furukawa S, Fujita T, Shimabukuro M, Iwaki M, Yamada Y, Nakajima Y, Nakayama O, Makishima M, Matsuda M, Shimomura I. Increased oxidative stress in obesity and its impact on metabolic syndrome. J Clin Invest. 2004;114:1752–1761.

[27]. Farhat, K., Sudarshan,K.R., Anil Dutta, S., and Vishawanathan, K.R. (2001). Proximate Composition and Mineral Content of Barks. The Indian. J. Nutr. 38: 93-97.
[28]. Garrison RJ, Kannel WB, Stokes J III, Castelli WP. Incidence and precursors of hypertension in young adults: the Framingham Offspring Study. Prev Med. 1987;16:235–251.
[29]. Hill, L. E.; Gomes, C.; Taylor, T. M. Characterization of Beta-Cyclodextrin Inclusion Complexes Containing Essential Oils (Trans-Cinnamaldehyde, Eugenol, Cinnamon Bark, and Clove Bud Extracts) for Antimicrobial Delivery Applications. LWT-Food Science and Technology 2013, 51(1), 86–93
[30]. How Does Cinnamon Reduce Blood Pressure? by BRENDA BARRON Aug. 14, 2017
[31]. Hossein N, Abolfazl M, Mahdi S, Ali K. Effect of Cinnamon zeylanicum essence and distillate on the clotting time. J Med Plants Res. 2013;7:1339-43.
[32]. Hussain, T., 1985. Food Composition Table for Pakistan. NWFP Agriculture Universty, Peshawar, pp: 26.
[33]. In book: Aromatic Plants from Asia Their Chemistry and Application in Food and Therapy, Edition: 1, Publisher: HarKrishanBhalla& Sons, Dehradun, India, Editors: L. Jitrovetz, N.X.Dung, V.K. Varshney, pp.49-7
[34]. International Journal of Home Science 2017; 3(1): 84-8
[35]. In vitro antioxidant activity and scavenging effects of Cinnamomum verum leaf extract assayed by different methodologies Author links open overlay panelSindhuMathewT. EmiliaAbraham Bioactive Polymer Engineering Section, Chemical Science Division, Regional Research Laboratory, Pappanamcode, Trivandrum 695 019, Kerala, India Received 24 June 2005, Accepted 24 June 2005, Available online 8 August 2005. https://doi.org/10.1016/j.fct.2005.06.013
[36]. ITIS by the Flora of North America Expertise Network, in connection with an update for USDA PLANTS (2007-2010)
[37]. Increased variance in blood pressure distribution and changing hypertension prevalence in an urban Indian population. Gupta R, Sharma AK, Gupta VP, Bhatnagar S, Rastogi S, Deedwania PC. J Hum Hypertens. 2003 Aug;17(8):535-40. PMID: 12874610.
[38]. Journal of Human Hypertension (2006) 20, 109–115 & 2006 Nature Publishing Group All rights reserved 0950-9240/06 $30.00 www.nature.com/jhh
[39]. Journal of Traditional and Complementary Medicine 5 (2015) 66e70
[40]. Journal of Paramedical Sciences (JPS) Winter 2011 Vol.2, No.1 ISSN 2008-4978
[41]. J. Thomas, K.M. Kuruvilla, in Handbook of Herbs and Spices (Second Edition), Volume 1, 2012
[42]. Journal of Medicinal Food VOL. 14, NO. 12 | 6 Dec 2011 https://doi.org/10.1089/jmf.2010.0300
[43]. Javed I, Faisal I, Zia Ur R, Khan MZ, Muhammad F, Aslam B, Ahmad M, Shahzadi A: Lipid lowering effect of cinnamomumzeylanicum in hyperlipidaemic albino rabbits. Pak J Pharm Sci 2012, 25:141-147.
[44]. Jeffrey A. CutlerPaul D. SorlieMichaelWolzThomasThomLarry E. Fields and Edward J. RoccellaOriginally published13 Oct 2008 Hypertension. 2008;52:818–827
[45]. J Agric Food Chem. 2013 Jul 3;61(26):6293-8. doi: 10.1021/jf401536y. Epub 2013 Jun 18. Methods for thermal stability enhancement of leaf essential oils and their main constituents from indigenous cinnamon (Cinnamomumosmophloeum). Yeh HF1, Luo CY, Lin CY, Cheng SS, Hsu YR, Chang ST.
[46]. J Agric Food Chem. 2014 Feb 19;62(7):1706-12. doi: 10.1021/jf405312q. Epub 2014 Feb 6. A potential low-coumarin cinnamon substitute: Cinnamomumosmophloeum leaves. Yeh TF1, Lin CY, Chang ST.
[47]. Kuete, in Medicinal Spices and Vegetables from Africa, 2017
[48]. Kwak, N. S.; Jukes, D. J. Functional Foods. Part 1: The Development of a Regulatory Concept. Food Control 2001, 12(2), 99–107.
[49]. KATHMANDU UNIVERSITY JOURNAL OF SCIENCE, ENGINEERING AND TECHNOLOGY VOL. 5, No. I, JANUARY, 2009, pp 143- 150.
[50]. Kumar, S.; Sharma, S.; Vasudeva, N. Chemical Compositions of Cinnamomum Tamala Oil from Two Different Regions of India. Asian Pacific Journal of Tropical Disease 2012, 2, S761–S764.
[51]. The effect of a cinnamon-, chromium- and magnesium-formulated honey on glycaemic control, weight loss and lipid parameters in type 2 diabetes: an open-label cross-over randomised controlled trial. Whitfield P1, Parry-Strong A2, Walsh E2, Weatherall M3, Krebs JD2,3.
[52]. Lin, C.-T.; Chen, C.-J.; Lin, T.-Y.; Tung, J. C.; Wang, S.-Y. Anti-Inflammation Activity of Fruit Essential Oil from CinnamomumInsularimontanumHayata. Bioresource Technology 2008, 99(18), 8783–8787
[53]. Lv, J.; Huang, H.; Yu, L.; Whent, M.; Niu, Y.; Shi, H.; Wang, T. T. Y.; Luthria, D.; Charles, D.; Yu, L. L. Phenolic Composition and Nutraceutical Properties of Organic and Conventional Cinnamon and Peppermint. Food Chemistry 2012, 132(3), 1442–1450.
[54]. Maheshwari, IJPRBS, 2013; Volume 2(5):131-14 Scientific Journal of Medical Research Vol. 1, Issue 3, pp 92 - 95, Summer 2017
[55]. Menrad, K.;. Market and Marketing of Functional Food in Europe. Journal of Food Engineering 2003, 56(2), 181–188.
[56]. Ministry of Health, Labour, and Welfare, Japan. Food for Specified Health Uses (FOSHU). http://www.mhlw.go.jp/english/topics/foodsafety/fhc/02.html. (accessed May 11, 2015).

[57]. Nutritive Value, Levels of Polyphenols and Anti-Nutritional Factors in Sri Lankan Cinnamon (CinnamomumZeyalnicum) And Chinese Cinnamon (Cinnamomum Cassia) Khalid S. Al-Numair Dilshad Ahmad, SaifEldein B. Ahmed Abdullah H. Al-Assaf Res. Bult., No. (154), Food Sci. & Agric. Res. Center, King Saud Univ., pp. (5-21) 2007
[58]. Nyadjeu et al. BMC Complementary and Alternative Medicine 2013, 13:27 http://www.biomedcentral.com/1472-6882/13/27
[59]. Psychologic factors as precursors to hypertension Current Hypertension Reports, 2001, Volume 3, Number 1, Page 25 Jerome H. Markovitz, Bruce S. Jonas, Karina Davidson
[60]. Risk factors for the development of hypertension: a 6-year longitudinal study of middle-aged Japanese men. Nakanishi N, Nakamura K, Ichikawa S, Suzuki K, Kawashimo H, Tatara K. J Hypertens. 1998 Jun;16(6):753-9.
[61]. PMID: 9663915
[62]. Stein, A. J.; Rodríguez-Cerezo, E. Functional Food in the European Union, a Report Based on the ESTO Study Functional Food in European Union; European Commission JRC IPTS: Seville, 2008.
[63]. Shumaila Gul and Mahpara Safdar, 2009. Proximate Composition and Mineral Analysis of Cinnamon. Pakistan Journal of Nutrition, 8: 1456-1460. DOI: 10.3923/pjn.2009.1456.1460
[64]. Sanjib Bhattacharya, in Essential Oils in Food Preservation, Flavor and Safety, 2016
[65]. Sambaiah K, Srinivasan K: Effect of cumin, cinnamon, ginger, mustard and tamarind in induced hypercholesterolemic rats. Nahrung 1991, 35:47-51.
[66]. School of Pharmacy, Second Military Medical University, Shanghai 200233, P.E. China
[67]. Shumaila Gul and Mahpara Safdar, 2009. Proximate Composition and Mineral Analysis of Cinnamon. Pakistan Journal of Nutrition, 8: 1456-1460. DOI:10.3923/pjn.2009.1456.1460URL:https://scialert.net/abstract/?doi=pjn.2009.1456.1460
[68]. Talpur, N.; Echard, B.; Ingram, C.; Bagchi, D.; Preuss, H. Effects of A Novel Formulation of Essential Oils on Glucose–Insulin Metabolism in Diabetic and Hypertensive Rats: A Pilot Study. Diabetes Obesity and Metabolism 2005, 7(2), 193–199.
[69]. Tung, Y.-T.; Chua, M.-T.; Wang, S.-Y.; Chang, S.-T. Anti-Inflammation Activities of Essential Oil and Its Constituents from Indigenous Cinnamon (CinnamomumOsmophloeum) Twigs. Bioresource Technology 2008, 99(9), 3908–3913.
[70]. Udayaprakash, N.K.; Ranjithkumar, M.; Deepa, S.; Sripriya, N.; Al-Arfaj, A. A.; Bhuvaneswari, S.Antioxidant, Free Radical Scavenging and GC–MS Composition of CinnamomumIners Reinw. Ex Blume. Industrial Crops and Products 2015, 69, 175–179.
[71]. Visceral Obesity The Link Among Inflammation, Hypertension, and Cardiovascular Disease Patrick Mathieu, Paul Poirier, Philippe Pibarot, Isabelle Lemieux, Jean-Pierre Despre´s Received June 30, 2008; first decision July 24, 2008; revision accepted January 21, 2009. From the Department of Surgery (P.M.), Division of Kinesiology, Department of Social and Preventive Medicine (I.L., J.-P.D.). (Hypertension. 2009;53:577-584.) © 2009 American Heart Association, Inc. DOI: 10.1161/HYPERTENSIONAHA.108.110320.
[72]. Wan Omar, A.; Ngah, Z. U.; Zaridah, M. Z.; Noor Rain, A. In Vitro and in Vivo Antiplasmodial Properties of Some Malaysian Plants Used in Traditional Medicine. Infectious Disease Journal2007, 16(4), 97–10.
[73]. Yan-Hong Wang, BharathiAvula, N. P. DhammikaNanayakkara, Jianping Zhao, and Ikhlas A. Khan Journal of Agricultural and Food Chemistry201361 (18), 4470-4476 DOI: 10.1021/jf400586
[74]. Zhongguo Zhong Yao Za Zhi. 2015 Dec;40(23):4568-72. [Research progress of trans-cinnamaldehyde pharmacological effects]. Zhang LQ, Zhang ZG, Fu Y, Xu Y. PMID: 27141665