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Microbiological quality and antimicrobial efficacy of fresh and dried Ceylon cinnamon (*Cinnamomum zeylanicum*)

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ABSTRACT

The bark of the cinnamon tree has a long history both as a spice and as a medicine. It has been reported that the healing abilities of cinnamon come from three basic types of components in the essential oils found in its bark. This present study was to assess the microbial contamination that might arise as a result of recommended drying methods and the efficacy of extracts from different dried cinnamon parts on selected microorganisms. Oven dried samples recorded no microflora due to the high temperature in the oven destroying all vegetative cells in the samples. The root bark samples had a higher microbial count than the stem barks. None of the extracts from both the dried stem and root barks was effective at inhibiting the growth of *E. coli*. Cold water and ethanol extracts of the stem bark did not have an inhibitory effect on *S. aureus*. Hot water extracts of the shade dried samples did not show any inhibitory effect on *Pseudomonas aeruginosa*. For the inhibition of *P. aeruginosa*, oven dried samples showed a higher zone of inhibition than samples dried under shade.

1.0 Introduction

Herbs and spices have long been used to improve the flavour of food without being considered as nutritionally significant ingredients [1]. However, the bioactive phenolic content of these plant-based products is currently attracting interest.

Cinnamon has a long history of medicinal use and continues to be valued for its therapeutic potential for improving metabolic disorders such as type 2 diabetes [2]. It has been reported by Cheng [2] that cinnamon polyphenol-enriched flour lowered blood glucose in diet-induced obese mice by inhibiting hepatic glucose production. Azab [3] concluded from their work that cinnamon extract might provide substantial protection against radiation-induced oxidative and inflammatory damages.

Some herbs are consumed in their fresh state and may deteriorate within a few days after harvest. Usually, traditional herbs are preferably preserved by drying in the sun or under a shade. Drying has been reported to inactivate the enzymes polyphenol oxidases of some herbs which may lead to significant changes in the composition of phytochemicals [4]. However, other studies have proved that the overall antioxidant properties of certain foods may instead be enhanced due to the formation of Maillard reaction products which results from a condensation reaction between amino acids (or proteins) and reducing sugars or lipid oxidation products [5].

Herbs may be contaminated because of the conditions under which they were cultivated and harvested. Drying can also predispose these herbs to fungal contamination. A recent study by Darfour [6] found that the drying increased the total phenolic and total flavonoid contents of cinnamon. They concluded that the best drying methods are the oven drying and shade/freeze drying.

This present study was to assess the microbial contamination that might arise as a result of the recommended drying methods on the recommended cinnamon plant parts and the efficacy of extracts from different dried cinnamon parts on selected microorganisms.

Materials and Methods

2.1 Plant materials

Fresh samples of stem bark and root bark of cinnamon (*Cinnamomum zeylanicum*) were collected at the Aburi Botanical Gardens of the Ghana Parks and Gardens Department.

2.2 Sample preparation

The fresh samples (stem bark and root bark) were washed under running tap water and then drained thoroughly on paper towel. The samples were then manually broken into pieces and dried using two methods (shade drying and oven drying).

Shade-drying

The herbs were evenly spread on a tray, covered with the cotton sheets to keep off dust and insects, turned occasionally and left to dry in the a shady place (35 ± 2°C) in appropriate air flow until the samples were brittle and considered to be dry (in four days).

Oven-drying

The samples were evenly spread on a tray and placed in an oven (Gallenkamp, United Kingdom). The samples were dried overnight at 50°C.

Both the fresh and dried samples were then ground and stored in air-tight containers at 4°C pending further analysis.

2.3 Effect of different drying methods on the microbial count

The effect of the different drying methods on the microbial count in cinnamon was assessed. Samples of the fresh, oven-dried and shade-dried cinnamon was incubated on

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plate count agar and recordings taken at 48 hours of incubation at 32 -35°C.

2.4 Microbial efficacy of cinnamon

Isolation of the Test Organisms

The test organisms used in this study consisted of two Gram-negative and one Gram-positive isolates (*Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli*) obtained from the Food and Medical laboratory of the Radiation Technology Centre of the Ghana Atomic Energy Commission. The test organisms were cultured on agar slants and stored in the refrigerator at 4°C. Subcultures were made at two-week intervals.

2.4.1 Preparation of extracts

Cold water, hot water or ethanol extracts were prepared in a ratio of 5g per 30ml. Five (5) grams of each sample was immersed in 30ml of each solvent. These were kept at room temperature (30±2°C) for 7 days. The samples were stirred every 24hrs to ensure effective and even extraction. The extracts were then heated for five minutes to obtain pure extracts of the root and bark of the plant. The extracts were stored at 5°C prior to use.

2.4.2 Inoculation of extracts

Antibacterial activity was assayed by disc diffusion method. For all bacteria strains (*Pseudomonas aeruginosa*, *Staphylococcus aureus and Escherichia coli*), overnight cultures grown on their respective agar plates were adjusted to an inoculum's density of 0.5 McFarland standard. Further, 20 µl was spread onto 20 ml of sterile Mueller Houtin agar plates by using a sterile micro pipette. The surface of the medium was allowed to dry for about 3min. Sterile filter paper discs (5 mm in diameter) impregnated with 20µl of different test extracts were then sited on the surface of these agar plates and labelled.

The plates were then incubated at 37±1°C for 24hours. The zone of inhibition was measured in millimeters using a transparent scale. Each extract was analyzed in triplicate, the mean values are presented.

3.0 Results and Discussion

It has been reported that the microbiological contamination of herbs arises from several sources, including the indigenous microflora of plants, microorganisms present in the air, post-harvest contamination from dust and from human contact [7].

The samples dried in the oven recorded no microflora (Table 1). This could have been due to the high temperature in the oven destroying all vegetative cells in the samples. Spores of the dried samples could however be present but had not resumed its vegetative activities. An extended storage might result in microbes being recorded in the oven dried samples.

Table 1. Effect of different drying methods on the microbial count of Ceylon cinnamon.

Drying method	Part of plant	Microbial count (CFU/g)
Fresh	Root bark	$2.8x10^3$
	Stem bark	$6.4x10^2$
Oven Drying	Root bark	≤10
	Stem bark	≤10
Shade Drying	Root bark	$2.3X10^5$
	Stem bark	9.2X10

Shade dried samples recorded microbial counts. The root bark samples had a higher count than the stem barks. This was expected as the root was in direct contact with the soil. Oven drying was a better option for the initial decontamination of *Cinnamomum zeylanicum.* This present finding corroborates the earlier finding by Darfour [6] on the most effective drying method for *Cinnamomum zeylanicum.*

During cleaning and processing, there is progressive reduction in the number and types of microorganisms; those remaining are usually aerobic spore-forming bacteria and common moulds [8]. This might account for the microbial count of the Ceylon cinnamon used in this work. Since it was cleaned prior to being used for the work, this might have accounted for the drastic reduction in the microflora.

Table 2. Antimicrobial efficacy of fresh Ceylon cinnamon root and stem barks.

Plant part	Test organism	Mean zone (mm)
Fresh root	E. coli	$0.00±0.03^c$
	Staphylococcus aureus	$9.33±1.86^a$
	Pseudomonas spp.	$5.00±0.71^b$
Fresh bark	E. coli	$0.00±0.03^c$
	Staphylococcus aureus	$12.33±1.63^a$
	Pseudomonas spp.	$6.00±1.42^b$

Mean of zones of inhibition (mm) ± standard error with different alphabets are significantly different ($P < 0.05$)

The bark of the fresh cinnamon was most effective at controlling *Staphylococcus aureus* with an inhibition zone of 12.33mm (Table 2). Both the root and stem barks could not inhibit the growth of *E. coli*. The fresh bark is better at

Table 3. Antimicrobial efficacy of dried Ceylon cinnamon stem bark after different methods of extraction.

Extraction Method	Pseudomonas aeruginosa		Staphylococcus aureus		Escherichia coli	
	Drying Method		Drying Method		Drying Method	
	Shade	Oven	Shade	Oven	Shade	Oven
Cold Water	$4.70±1.40^b{}_y$	$8.00±1.40^a{}_x$	$0.0±0.03^c{}_y$	$0.0±0.03^c{}_y$	$0.0±0.03^c{}_x$	$0.0±0.03^c{}_x$
Hot Water	$0.00±0.04^c{}_z$	$4.70±1.40^b{}_y$	$8.30±0.03^a{}_x$	$1.03±0.03^c{}_x$	$0.0±0.03^c{}_x$	$0.0±0.03^c{}_x$
Ethanol	$8.70±1.40^a{}_x$	$9.20±1.40^a{}_x$	$0.0±0.03^b{}_y$	$0.0±0.03^b{}_y$	$0.0±0.03^b{}_x$	$0.0±0.03^a{}_x$

Means of zones of inhibition (mm) ± standard error with different superscript alphabets on the same row are significantly different ($P < 0.05$), and Means of zones of inhibition (mm) ± standard error with different subscript alphabets on the same column are significantly different ($P < 0.05$).

Table 4. Antimicrobial efficacy of dried Ceylon cinnamon root bark.

Extraction Method	Pseudomonas aeruginosa		Staphylococcus aureus		Escherichia coli	
	Drying Method		Drying Method		Drying Method	
	Shade	Oven	Shade	Oven	Shade	Oven
Cold Water	$4.70±1.90^b{}_y$	$8.00±1.90^a{}_x$	$0.0±0.11^c{}_y$	$0.0±0.11^c{}_x$	$0.0±0.07^c{}_x$	$0.0±0.07^c{}_x$
Hot Water	$5.50±1.90^a{}_y$	$7.20±1.90^a{}_x$	$0.0±0.11^b{}_y$	$0.0±0.11^b{}_x$	$0.0±0.07^b{}_x$	$0.0±0.07^b{}_x$
Ethanol	$8.30±1.90^a{}_x$	$6.00±1.90^b{}_x$	$5.50±1.10^a{}_x$	$0.0±0.11^c{}_x$	$0.0±0.07^c{}_x$	$0.0±0.07^c{}_x$

Means of zones of inhibition (mm) ± standard error with different superscript alphabets on the same row are significantly different ($P < 0.05$), and Means of zones of inhibition (mm) ± standard error with different subscript alphabets on the same column are significantly different ($P < 0.05$).

inhibiting the growth of *Pseudomonas* spp. than the fresh root samples.

Results of the antimicrobial efficacy of dried Ceylon cinnamon stem and root barks are shown in Tables 3 and 4. None of the extracts from both the dried stem and root barks was effective at inhibiting the growth of *E. coli* (Tables 3 and 4). This is similar to the results obtained by Ababutain [9]. Mukhtar and Ghori [10] however made a contrary observation. According to their work, 60% to 100% aqueous extract of cinnamon was able to inhibit the growth of *E coli*. All the concentrations of the ethanol extract in the work of Mukhtar and Ghori [10] had an inhibitory effect on *E coli*.

Cold water and ethanol extracts of the stem bark did not have an inhibitory effect on *S. aureus*. Hot water extracts of the shade dried samples did not show any inhibitory effect on *Pseudomonas aeruginosa*. For the inhibition of *P. aeruginosa*, oven dried samples showed a higher zone of inhibition than samples dried under shade (Table 3).

Generally with the exception of samples dried in shade and extracted with ethanol, the extracts of the root bark did not have an inhibitory effect on *S. aureus* (Table 4). In the case of *Pseudomonas aeruginosa*, extracts from the oven dried root samples generally had a higher zone of inhibition than samples dried under shade.

Wendakoon and Sakaguchi [11] stated that the antibacterial activity of cinnamon might be due to the presence of cinnamaldehyde compound which inhibits the amino acid decarboxylation activity in the cells which leads to energy deprivation and microbial cell death. The results of the present work revealed that generally the ethanol extracts of the stem and root barks of cinnamon showed better degrees of growth inhibition, depending on the bacterial strains, than the cold and hot water extracts (Tables 3 and 4).

It is well known that most spices and medicinal herbs are more active against Gram-positive bacteria than Gram-negative bacteria [12]. Generally, the Gram negative *E.coli* was comparatively more resistant to the extracts than all the other organisms probably due to the structural differences in the cell membrane and cell wall structure. *Pseudomonas aeruginosa*, which is also a Gram negative bacterium, was however inhibited by the extracts of the root and stem barks of cinnamon.

4.0 Conclusion

The study has shown that none of the extracts of *Cinnamomum zeylanicum* inhibited the growth of the food spoilage bacteria *E. coli*. However, extracts were effective at controlling the growth of *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

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