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EFFECTS OF TEMPERATURE AND TIME OF ROASTING ON THE PHYSICOCHEMICAL AND ANTIMICROBIAL CHARACTERISTICS OF CINNAMON BARK OIL

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Keywords:

Antioxidant, Antimicrobial, Physical properties, Composition, Roasting

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ABSTRACT: The purpose of the present study was to examine the influences of roasting and the effects of roasting temperature and duration on the chemical composition of cinnamon bark oil and to extend our knowledge concerning the changes in antioxidant activity, antimicrobial activity, physical properties such as colour, refractive index, density and contents of cinnamaldehyde and other components of cinnamon bark oil. Roasted Cinnamon barks were extracted using (40-60 ºC b.p) petroleum ether. Roasting increased the oil content of the cinnamon bark significantly ($P<0.05$). Maximum oil yield was observed at 100°c for 10 min (10.78 ± 0.03). Analysis of the extracted aromatic oils demonstrated a significant increase in antioxidant activity, total phenolic content, antimicrobial activity, density and also a significant decrease in refractive index and colour values for roasting periods of 10 to 30 min. An increase in the amounts of cinnamaldehyde of the roasted cinnamon bark oils was also found at 1800c for 10 min. However, during roasting 8-Allyl-8-methyl-3-Oxabicyclo [4.2.0] Oct-5-ene was generated. The results obtained lead to conclude that roasting at 80 ºC for 20 min, 100 °C for 20 minutes and 180 °C for 10 min would allow the development of the organoleptic properties of the oil without compromising its antioxidant activity.

INTRODUCTION: Spices are applied in culinary preparation intrinsically or in roasted forms to enhance the flavour of foods and keep antioxidants of food. So, roasting may be a vital step all through cooking. So it's vital to recognize the time and temperature of roasting of spices to keep their antioxidant activities. Spices when heated generate continually flavour vapours which can be generally lost throughout culinary preparation.

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Cinnamomum (Lauraceace) belongs to an evergreen tree. It's originating in southern China and is widely cultivated within the countries of eastern and southern Asia (India, Thailand, Malaysia, Indonesia, Vietnam, and Laos) [1]. There are three known cinnamon spices in India.

They're cassia, cinnamon, and *Cinnamomum burmanni* [2]. Cassia is characterized by a sweet-spicy aroma, pungent, bitter taste, and thicker bark. The cinnamon bark is rich in cinnamic aldehyde, while the leaves and roots are rich in eugenol and camphor, respectively. Cinnamon bark oil was found to be a singular aromatic monoterpene-rich natural source, with trans–cinnamaldehyde [3]. Researches show that cinnamon oil (*Cinnamomum*

cassia) presents some phenolic compounds, and therefore the major components are cinnamyl acetate, cinnamic aldehyde and eucalyptol [4]. The antimicrobial activities of cinnamon bark oil are proved against several Escherichia coli (*E. coli*), *Bacillus cereus*, and *Staphylococcus aureus*. Strong antibacterial activity of the cinnamon bark oil is especially thanks to the presence of cinnamaldehyde at high levels. Recently, an increasing number of investigations on antioxidant activity of spices are reported [5, 6, 7, 8]. Heat treatment is one of the effective methods to liberate antioxidants and to get natural antioxidants from plants [9, 10, 11, 12]. This process is administered at heat for a brief time, which may alter the efficacy of bioactive compounds. Heat treatment of varied food products, including spices, has been used as an effective tool for their microbial decontamination, disinfestations, and also their long-term preservation. The formation of antioxidants during thermal treatment, considered to be the first effect of Maillard browning reactions, can positively influence the entire antioxidant status of food also [13, 10].

The purpose of the present study was to explore the influences of hot plate roasting on the physic-chemical characteristics of cinnamon bark oil and to extend our knowledge concerning the changes in antioxidant and antimicrobial activities in cinnamon bark oil extracted at different time and temperature of roasting during hot plate roasting.

MATERIALS AND METHODS: Cinnamon barks were purchased from the local market of Kolkata, West Bengal, India. All the analytical grade chemicals and solvents were purchased from MERCK, India.

Preparation of Samples: At first, cinnamon barks were weighed around 10 gm on a laboratory-based weighing balance. Then, cinnamon barks were roasted on a hot plate (Remi 1MLH) with continuous stirring, and roasting temperatures of 80, 100 and 180° C were applied for the duration of 10, 20, or 30 min. Roasting was done in a flat bottom container (50 ml) with an air-tight lid to trap the vapour. The time of warmth treatment was standardized after initial trials with each sample. The roasted cinnamon barks were ground to powder form employing a laboratory grinder (Bajaj Classic Mixer Grinder). An impact sample of cinnamon bark powder was obtained from unroasted cinnamon barks.

Oil Extraction: After hotplate roasting, the above roasted and unroasted cinnamon bark powder was mixed and dipped in 50ml of petroleum ether (40-60 °C) for overnight. The next day, the solution was filtered. After filtration, the filtrate was fed into a Soxhlet extractor fitted with a 100-mL round-bottomed flask and a condenser. The extraction was carried out on a water bath (40-50 °C) for 1 h. After extraction, the solvent was distilled off.

Physical Properties: Yield of Extraction of aromatic oils from cinnamon bark before and after roasting. The percentage yield for cinnamon bark before and after roasting were calculated by using the following equation [14].

Volatile oil (%) = (Weight of the volatile oil recovered in g/ Weight of sample taken in g) × 100

Color, Density and Refractive Index of Aromatic Oils from Cinnamon Bark Before and after Roasting: The physical properties of aromatic oils from cinnamon bark before and after roasting such as color, density and refractive index per AOAC standard methods 15 were evaluated.

Color Property of Aromatic Oils from Cinnamon Bark before and after Roasting: Color intensities of roasted and unroasted aromatic oil samples were measured by use of the colorimeter (Konica Minolta CR 10) which gave the Hunter parameter (L*, a*, b*) and also c*and h* values directly 16. 2 ml of samples were placed in Petri dishes with a cover.

Colour was measured within 5 min of the sample preparation. L* indicated lightness which describes transmitting capacity and the light reflecting of an object. Color analysis was performed by determination of a* (− green to + red component), b* (−blue to yellow), c* (chroma), and h*(hueangle) values in triplicates

Determination of Total Polyphenols (TPC) of Aromatic Oils from Cinnamon bark before and after Roasting: Total polyphenols content (TPC) was determined by previous literature [17].

Determination of Antioxidant Activity of Aromatic Oils from Cinnamon Bark before and after Roasting:

DPPH Free Radical Scavenging Activity Assay: The total antioxidant capacity of unroasted and different heat-treated plant aromatic oil samples was determined spectrophotometrically, assessed using 1, 1-diphenyl 2-picryl hydrazyl (DPPH) as followed by previous literature [18].

Ferric Reducing Antioxidant Power (FRAP): The ferric ions (Fe^{3+}) reducing antioxidant power (FRAP) method was used to measure the reducing capacity of different heat-treated plant essential oils, described by previous literature [19].

ABTS Free radical scavenging activity: $ABTS^{+}$ assays were done by the modified procedure also described in previous literature [20].

GC-MS Analysis of Aromatic Oils from Cinnamon Bark before and after Roasting: Different heat-treated aromatic oil samples were analyzed using GC-MS (Thermo Scientific). A fused silica capillary column DB5-MS (30 m × 0.25 mm, film thickness 0.25 µm) was used with helium as the carrier gas at a constant pressure of 100kPa, at a flow rate of 1 ml/min. The injector and detector temperature was 250 °C. The components of the essential oil were identified based on a comparison of their retention indexes (RI), mass spectra (NIST library), and literature data.

Fourier - Transformed Infrared Spectroscopy (FT-IR) Analysis of Aromatic Oils from Cinnamon Bark before and after Roasting: The FT-IR spectrum of essential oil was obtained using Bruker 55 model FT-IR spectrometer and the functional groups were identified with the help of IR correlation charts. The wavenumber region for the analysis was 800–4000 cm^{-1}.

Antimicrobial Activity of Aromatic Oils from Cinnamon Bark before and after Roasting: The antimicrobial activity of cinnamon bark oil derived from roasted and unroasted cinnamon bark against different bacterial pathogens was evaluated using a well diffusion assay. The oil (1 ml) was dissolved in distilled water (total volume 10 ml) using 100 µl of tween 80 for use in antimicrobial studies. Bacterial strains were maintained in nutrient agar plates and subcultured at regular intervals. For evaluating antibacterial efficacy of plant essential oils, two Gram-positive bacteria (*Bacillus subtilis*, *Staphyloccocus aureus*) and two Gram-negative bacteria (*Escherichia coli*, *Enterobactor aerogenes*) were tested in well diffusion assay.

All the above-mentioned bacteria were incubated at 30 ± 0.2 °C for 24 h by inoculation into Nutrient Broth. Muller-Hinton agar (MHA) sterilized in a flask and cooled to 45–50 °C, was distributed by pipette (20 ml) into each inoculated Petri dish and swirled to distribute the medium homogeneously. Petri dishes with (MHA) were inoculated with 10 µl of each bacterial strain. The wells (10 mm diameter) were made in the nutrient agar plate by a cork borer. Different heat-treated plant essential oils (10 µl) were added individually to the petri plate containing 20 ml of molten nutrient agar media. Petri plates were kept under aseptic conditions and incubated for 24 h at 37 °C and observed for bacterial growth, and the diameter of the inhibition zone (mm) was measured.

Statistical Analysis: Each analysis was carried out in triplicate. The results were expressed as mean values and standard deviation. The statistical analysis was done by Tukey test ($p < 0.05$) for intergroup comparison of parametric data using Origin 8 software.

RESULTS AND DISCUSSION:

Physical Properties:

Yield of Extraction of Aromatic Oils from Cinnamon Bark before and after Roasting: The percentage yield for unroasted cinnamon bark estimated was 6.89%. From **Table 1**, the maximum oil yield was 10.78 gm/100 gm which was achieved at 100 ºC roasting temperature for 10 min. roasting duration. The minimum oil yield was 7.02% which was achieved at 80 ºC roasting temperature for 10 min. roasting duration. Analysis of variance of the data showed a significant effect ($p<0.05$) of treatment on response, but there were insignificant differences observed between 80 ºC and 180 ºC for 10 min and also 100 ºC and 180 ºC for 30 min. This indicates the variation of roasting duration and temperature effects on oil yield. The method of preparation of cinnamon bark powder influences the oil yield. The whole roasting process was administered during a sealed container which helps to stop vapour out. That's far more cell rapture was

happened with increasing time and temperature, which will results in more vapourization and increase the oil yield. Heating of oilseeds break-down oil cells, adjust moisture contents of the meal to the optimal value for extraction, coagulation of the protein, and reduce oil viscosity.

Color, Density and Refractive Index of Aromatic Oils from Cinnamon Bark before and after Roasting: The color of the oil extracted from micro-waved cinnamon bark oil changed from light yellow to yellow and brown in the course of roasting with increasing time and temperature **Table 1**.

Thus, by increasing the roasting time and temperature, the colour of cinnamon bark oil became darker, presumably due to the oxidation of phenolic compounds.

The longer the roasting time, the greater was the intensification of the colour. The density of the control oils was 0.91 g/cm^3. Roasting increased the densities of the oils in a time and temperature-dependent manner **Table 1**. The density of oil was increased at 2.04 g/cm^3 for 180 °C at 30 min. This increase of oil density may reflect the occurrence of polymerization, which makes the oil denser. The oil density was significantly ($p<0.05$) dependent on heat treatments, but there were insignificant differences observed between 20 min and 30 min at 80 ºC, 10 min and 20 min, 20 min and 30 min at 180 ºC. The treatments influence the oil refractive index significantly ($p > 0.05$). From **Table 1**, a decrease in the refractive index of the oil was observed with increase in both roasting temperature and duration.

TABLE 1: PHYSICAL PROPERTIES OF AROMATIC OILS FROM CINNAMON BARK BEFORE AND AFTER ROASTING

Roasting Conditions	Oil Yield (g/100g)	Colour	Density (g/cm^3, 25 °C)	Refractive Index
Control	6.89±0.01a	Golden yellow	0.91±0.005a	1.51±0.01a
80°c				
10 min	7.02 ± 0.02b	Dark Yellow	1.02±0.01b	1.41±0.005b
20 min	9.58 ± 0.15ch	Dark Yellow	1.10±0.01cd	1.33±0.02c
30 min	7.79 ± 0.05d	Dark Yellow	1.14±0.02d	1.25±0.01d
100°c				
10 min	10.78±0.03e	Dark yellow	1.25±0.03e	1.18±0.02e
20 min	10.34±0.04f	Brown	1.59±0.14f	1.11±0.01f
30 min	10.01±0.01gj	Brown	1.78±0.04g	1.04±0.01gh
180°c				
10 min	9.59±0.02h	Brown	1.89±0.01hi	1.03±0.02h
20 min	8.00±0.005i	Brown	1.96±0.03ij	0.94±0.05i
30 min	10.03±0.01j	Brown	2.04±0.01j	0.81±0.005j

Values are in terms of mean ± SD after triplicate analysis. Different letter (a,b,c,d,e,f,g,h,i,j) in a coloum represents significant differences (P<0.05)

TABLE 2: COLOUR PROPERTIES OF AROMATIC OILS FROM CINNAMON BARK BEFORE AND AFTER ROASTING

Roasting Conditions	L	a*	b*	C	H
Control 80°c	28.94±0.04^a	0.57±0.05^a	5.92±0.02^a	6.63±0.02^a	115.50±0.05^a
10 min	26.24±0.02^b	0.75±0.04^b	5.05±0.02^b	6.89±0.08^b	121.64±0.04^b
20 min	25.09±0.05^c	0.73±0.20^c	4.84±0.02^{ce}	7.06±0.04^{cd}	128.85±0.04^c
30 min 100°c	23.26±0.04^d	1.03±0.01^{de}	4.62±0.01^d	7.12±0.02^d	131.35±0.02^d
10 min	21.12±0.02^e	1.14±0.02^{ef}	4.75±0.04^e	7.29±0.02^e	141.64±0.04^e
20 min	20.30±0.04^f	1.27±0.05^{fg}	4.40±0.12^f	7.65±0.04^f	152.24±0.04^f
30 min 180°c	18.86±0.04^g	1.37±0.03^g	4.18±0.03^g	7.96±0.02^g	166.65±0.02^g
10 min	17.77±0.02^h	1.54±0.04^{hi}	4.04±0.01^h	8.11±0.05^h	171.69±0.01^h
20 min	15.53±0.03^i	1.63±0.02^i	3.85±0.02^i	8.23±0.02^i	184.47±0.01^i
30 min	13.39±0.06^j	1.78±0.005^j	3.46±0.02^j	8.32±0.02^j	192.31±0.08^j

Values are in terms of mean ± SD after triplicate analysis. Different letter (a,b,c,d,e,f,g,h,i,j) in a coloum represents significant differences (P<0.05)

Colour Property of Aromatic Oils from Cinnamon Bark before and after Roasting: The oil color was significantly ($p<0.05$) dependent on heat treatments. An increase in both roasting

temperature and duration increased colour of the extracted oil **Table 2**. Change in color in aromatic oil samples was an important parameter in assessing the quality of the oils. L* values of unroasted cinnamon bark oil were 28.94 ± 0.04, which is significantly decreased for hotplate roasted samples with increasing time and temperature. It means that roasted oils were darker compared with unroasted one.

A decrease in L values indicated decreasing of lightness of aromatic oil samples. An increase in a* values indicated positive values for reddish colour of aromatic oil samples and also increased in b* values indicated the yellowish colour of aromatic oil samples Hue-angle values fluctuated in a narrow range of 115.50 ± 0.05-192.31 ± 0.08. However, chroma had higher values for roasted oil samples compared to unroasted ones.

Total Polyphenols (TPC) Content of Aromatic Oils from Cinnamon Bark before and after Roasting: In the present studies of a different time and temperature of roasting process **Table 3**, total phenol content (mgGAE/ml) in cinnamon barks oil without heat treatment was 0.17 which increased during roasting.

The extent of increase of TPC was more prominent 80 °C heated samples. TPC was higher for samples which were treated at 80 °C for 10 min. The results indicated that total phenolic content significantly decreased with increasing roasting temperature.

TABLE 3: TOTAL PHENOLIC CONTENT (TPC) OF AROMATIC OILS FROM CINNAMON BARK BEFORE AND AFTER ROASTING

Roasting Conditions	TPC(mgGAE/ml)
Control 80°c	0.17±0.007[a]
10 min	1.39±0.01[b]
20 min	1.12±0.02[c]
30 min 100°c	1.25±0.04[de]
10 min	1.19±0.01[e]
20 min	0.92±0.02[f]
30 min 180°c	0.75±0.03[gj]
10 min	1.01±0.02[h]
20 min	0.67±0.01[i]
30 min	0.81±0.06[j]

Values are in terms of mean ± SD after triplicate analysis. Different letter (a,b,c,d,e,f,g,h,i,j) in a coloum represents significant differences (P<0.05)

Antioxidant Activity of Aromatic Oils from Cinnamon bark before and after Roasting: The results of the antioxidant activity content of aromatic oils from cinnamon bark before and after roasting are included in **Table 4**.

The ferric ions (Fe^{3+}) reducing antioxidant power (FRAP) method was used to measure the reducing capacity of all oil samples. During roasting, there were significant differences observed between all heated samples. The lowest reducing power was observed for unroasted samples and also for roasted samples, which were roasted at 80 °C for 30 min. Maximum reducing power was observed at 180 °C for 10 min.

TABLE 4: ANTIOXIDANT ACTIVITY OF AROMATIC OILS FROM CINNAMON BARK BEFORE AND AFTER ROASTING

Roasting Conditions	DPPH (%)	ABTS (%)	FRAP(µM/ml)
Control 80°c	80.15±0.08[a]	75.76±0.04[a]	10.31±0.05[a]
10 min	82.36±0.05[b]	77.24±0.02[b]	12.06±0.02[b]
20 min	84.69±0.03[c]	78.96±0.02[c]	14.15±0.04[c]
30 min 100°c	81.09±0.03[d]	76.35±0.03[d]	11.17±0.02[d]
10 min	86.05±0.03[e]	80.46±0.01[e]	14.45±0.03[e]
20 min	87.99±0.03[f]	83.38±0.02[f]	15.87±0.02[f]
30 min 180°c	85.81±0.04[g]	78.54±0.05[g]	14.05±0.02[g]
10 min	88.72±0.09[h]	83.72±0.12[h]	17.67±0.04[h]
20 min	86.61±0.07[i]	81.07±0.05[i]	15.07±0.03[i]
30 min	87.07±0.06[j]	82.27±0.05[j]	16.58±0.03[j]

Values are in terms of mean ± SD after triplicate analysis. Different letter (a,b,c,d,e,f,g,h,i,j) in a coloum represents significant differences (P<0.05)

Furthermore, during roasting, cinnamon bark oils were characterized by a steady increase in the DPPH radical scavenging capacity (82.36 - 88.72%). DPPH presented the highest scavenging power for 180 °C at 10 min samples. There were significant differences observed between roasted and unroasted samples. The lowest scavenging power activity was observed for unroasted samples.

During roasting, cinnamon bark oils were characterized by a steady increase in the ABTS+ radical scavenging activity (77.24-83.72%). Significant differences were observed between samples with increasing time and temperature.

There are many literature studies that support similar observations, which indicate that thermal treatments improve antioxidant properties of spices [21, 22]. It has already been stated 23 that the vapors of roasted clove bud have antioxidant activity.

To do this, the entire roasting process has been carried out in a sealed container to avoid loss of

flavor. This system facilitates to increase cell rapture, increase the concentration of water, increase the release of molecular activity and thus helps to increase the availability of antioxidant compounds. For that reason, roasted samples confirmed greater antioxidant activity in comparison to unroasted ones. Roasted oil samples suggest greater anti-oxidant sports due to their chemical composition.

GC-MS Study of Aromatic Oils from Cinnamon Bark before and after Roasting: Chemical compositions in major constituents of aromatic oils before and after roasting are given in **Table 5**.

The identification was made based on the retention time, literature data, and library search (NIST) of the mass spectra of the pecks. **Fig. 1**, **2**, **3** and **4** were represented GC-MS chromatography of major constituents of unroasted and roasted cinnamon bark oils.

Table 5 shows the major constituents of the roasted and unroasted cinnamon bark oil. The chemical composition of the control cinnamon bark oil was cinnamaldehyde in concentrations of 87.98%, respectively.

When cinnamon barks were roasted in a hotplate for 10, 20, and 30 min at 80 °C, 100 °C, and 180 °C, there was little change in the composition of the oils.

The longer the roasting time, the higher was the amount of the cinnamaldehyde relative to the control sample. But during roasting at 180 °C for 10 min, the higher the level of cinnamaldehyde content is highest compared to other roasted samples.

The chemical components of the roasted cinnamon bark oil were cinnamaldehyde, isoeugenol, alpha-cubebene, coumarin, 8-Allyl-8-methyl-3-Oxabicyclo [4.2.0]Oct-5-ene. As a result, roasting was carried out in an airtight container, with further vapors condensed into the container, which may contribute to the creation of more materials. As a result, the compositions of various roasted aromatic oils were different from unroasted ones.

TABLE 5: CHEMICAL COMPOSITIONS IN MAJOR CONSTITUENTS OF CINNAMON BARK OIL BEFORE AND AFTER ROASTING AS DETERMINED BY GC-MS

Compound Name	Retention Time	Control	Roasting Condition								
			80 °C			100 °C			180 °C		
			10 min	20 min	30 min	10 min	20 min	30 min	10 min	20 min	30 min
Cinnamaldehyde	15.84	87.98%	64.6%	67.3%	62.2%	81.9%	82.1%	81.4%	88.8%	86.0%	87.8%
Isoeugenol	17.55	7.55%	16.4%	12.2%	13.4%	13.4%	5.55%	5.78%	4.20%	3.40%	2.88%
Alpha-cubebene	18.06	1.51%	6.66%	8.66%	10.0%	2.25%	3.63%	5.38%	2.08%	2.01%	1.81%
Coumarin	19.59	2.9%	-12.1%	-	-	2.40%	1.90%	-	1.62%	1.73%	1.21%
8-Allyl-8-methyl-3-Oxabicyclo-[4.2.0]Oct-5-ene	21.03	-		11.7%	14.1%	-	6.77%	7.40%	3.86%	6.81	6.27%

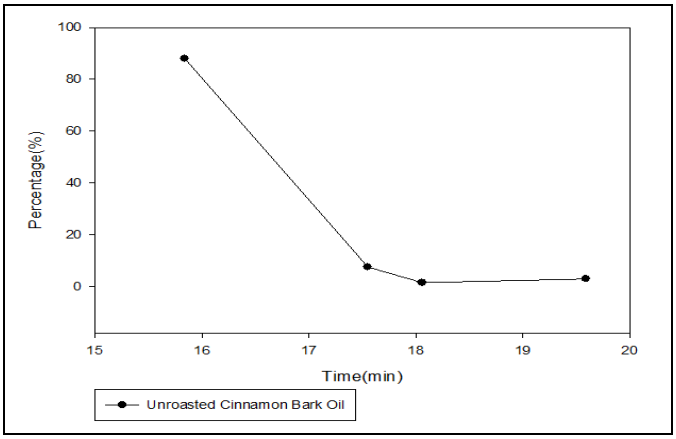

FIG. 1: GC-MS CHROMATROGRAPH OF AROMATIC OILS FROM CINNAMON BARK OIL BEFORE ROASTING

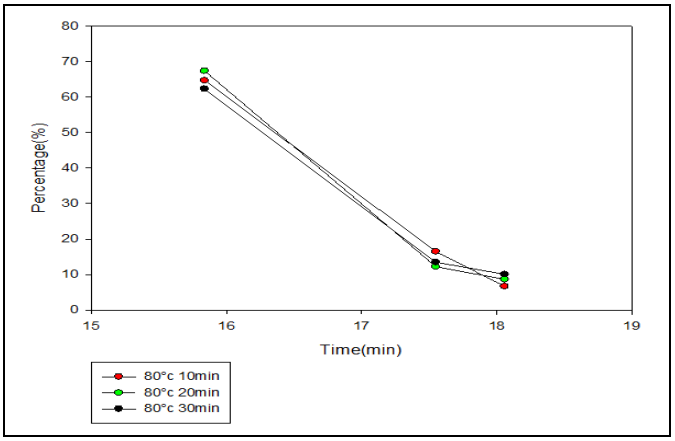

FIG. 2: GC-MS CHROMATROGRAPH OF AROMATIC OILS FROM CINNAMON BARK OIL AFTER ROASTING AT 80 ºC FOR 10 MIN, 20 MIN, 30 MIN

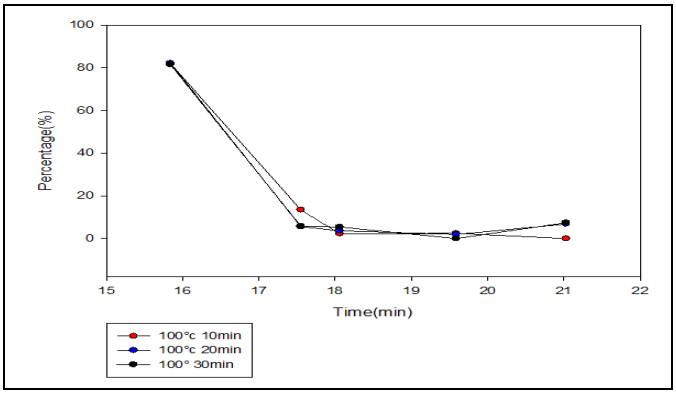

FIG. 3: GC-MS CHROMATROGRAPH OF AROMATIC OILS FROM CINNAMON BARK OIL AFTER ROASTING AT 100 ºC FOR 10 MIN, 20 MIN, 30 MIN

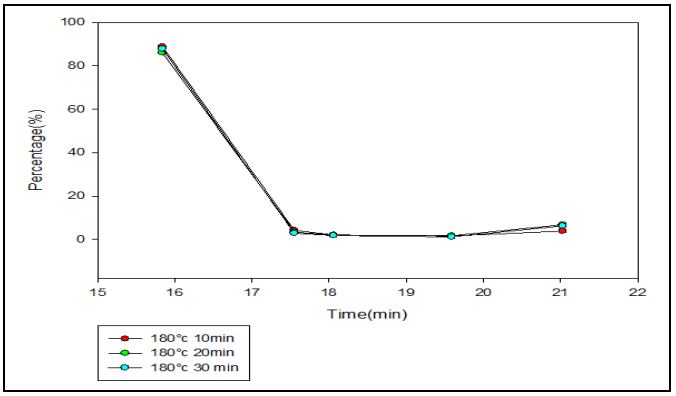

FIG. 4: GC-MS CHROMATROGRAPH OF AROMATIC OILS FROM CINNAMON BARK OIL AFTER ROASTING AT 180 ºC FOR 10 MIN, 20 MIN, 30 MIN

TABLE 6: FTIR OF CINNAMON BARK OIL BEFORE AND AFTER ROASTING

URCiBO	Position of Bands ($^{cm-1}$)								
	HRCiBO								
	80 ºC			100 ºC			180 ºC		
	10 min	20 min	30 min	10 min	20 min	30 min	10 min	20 min	30 min
3343,2741	2737	-	-	-	2740,2816	2743	-	-	-
3063,3029, 974	3058, 3026,750	3063,974, 750, 690	3060	3062	3063,974, 757,686	3062,975, 751, 691	970,749, 747, 829	3059,750, 974,689,682	3061,972, 744, 686
2859,2958, 2931, 2874,1384	2925, 2855	2921, 2853	2922, 2850	2851,2927, 970,747, 687	29272850	2925, 2850	2926, 2854	2851, 2924	2924, 2815
1971,1734, 1452	1514,157 8,1677	1732, 167, 1451	1732, 1676	1732,1672	1729,1671	1730, 167, 1451	-	1728	1673, 1732
2241	-	2357	-	-	-	-	-	-	-
-	-	-	-	-	-	-	1679, 1726	1677	-
1498	-	-	1448	1451	1451	-	-	1290	-
1681,1127, 1253, 1293	1293	1121, 1294	1294	-	-	1254	-	-	-
-	-	-	-	-	-	-	-	-	1117
-	-	-	-	-	-	-	-	-	-

URCiBO = Unroasted Cinnamon Bark Oil, HRCiBO = Hotplate roasted Cinnamon Bark Oil, MRCiBO = Microwave Roasted Cinnamon Bark Oil

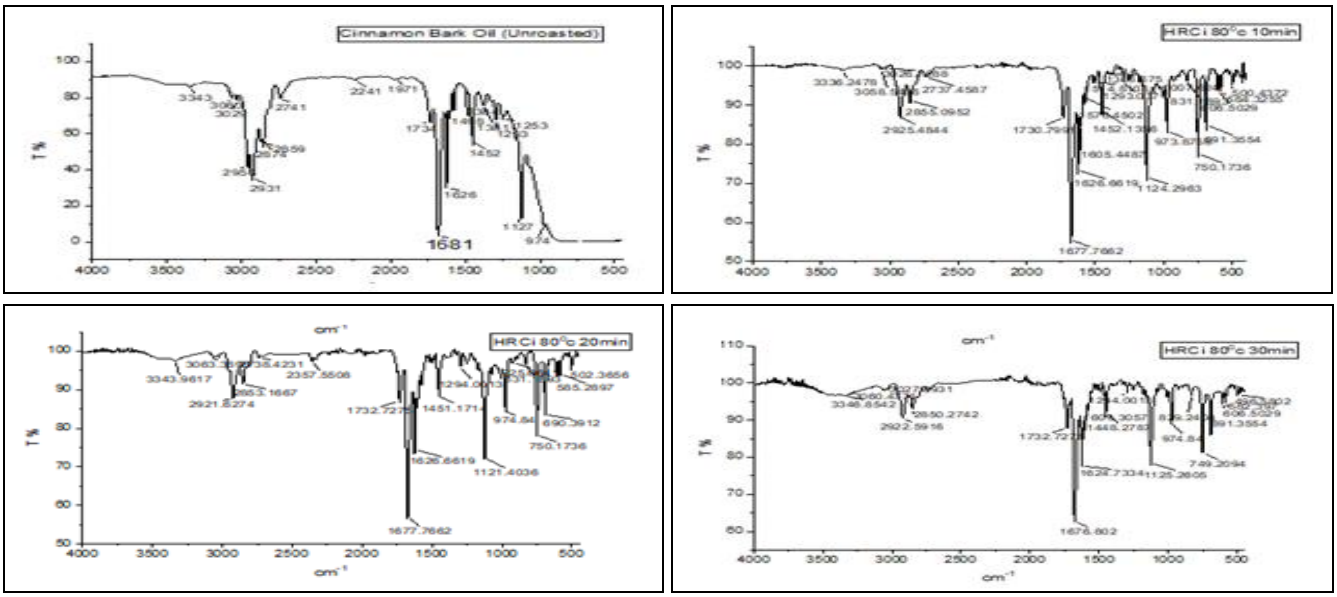

FIG. 5: FTIR OF AROMATIC OILS FROM CINNAMON BARK OIL BEFORE AND AFTER HOTPLATE ROASTING AT 80 ºC FOR 10 MIN, 20 MIN, 30 MIN

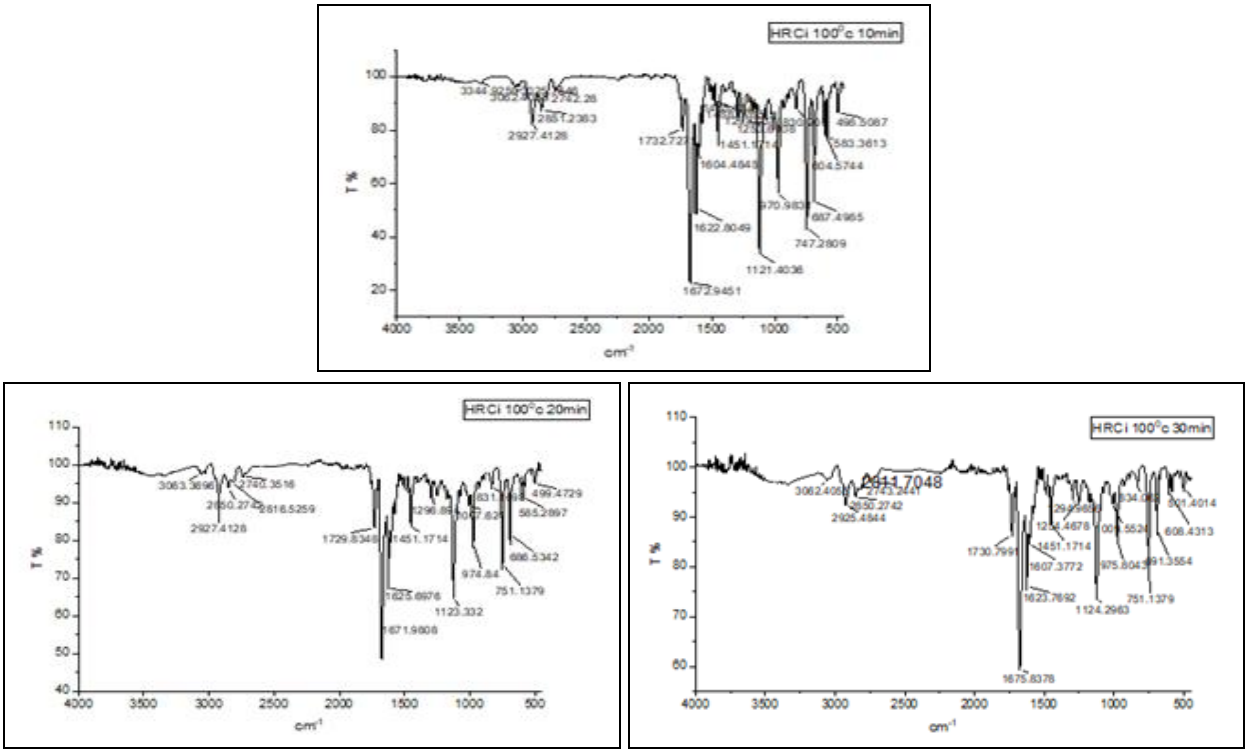

FIG. 6: FTIR OF AROMATIC OILS FROM CINNAMON BARK OIL AFTER HOTPLATE ROASTING AT 100 ºC FOR 10 MIN, 20 MIN, 30 MIN

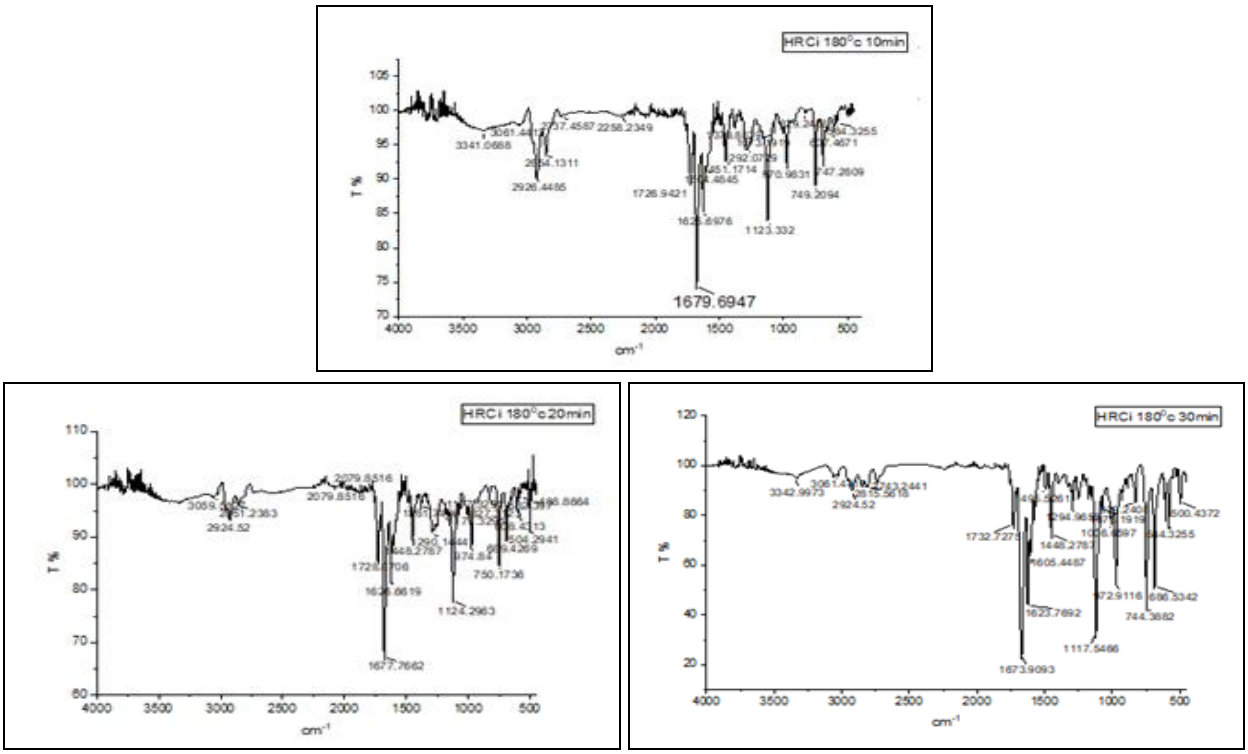

FIG.7. FTIR OF AROMATIC OILS FROM CINNAMON BARK OIL AFTER HOTPLATE ROASTING AT 180 ºC FOR 10 MIN, 20 MIN, 30 MIN

FTIR of Aromatic Oils from Cinnamon Bark before and after Roasting: Fourier transformed infrared spectroscopy is one of the most widely employed techniques for the identification of functional groups. **Fig. 5** to **7** and **Table 6** showed the infrared spectra and the characteristic bands observed in aromatic oils from cinnamon bark oil before and after roasting in the range of 4000-500 cm^{-1}. The detailed and complete study of a spectrum is an operation rarely practiced in current

interpretation because of the complexity of the analysis. It is therefore often limited to identifying functional groups through the location of the different bands on the spectrum.

Antimicrobial Assay of Aromatic Oils from Cinnamon Bark before and after Roasting: Development inhibition experiments have been performed in vitro to examine the antimicrobial action of various heated cinnamon bark oils against the microorganisms studied.

The result has been presented in **Table 6**. Growth inhibition pattern showed that roasted cinnamon bark oil was more effective than unroasted cinnamon bark oil.

The highest inhibition zone was developed against *E. coli* with an IZD of 26.90 mm at 180 °C for 10 min. Significant changes were noted between all samples. Since 180 °C for 10 min samples has the more antioxidant capacity, it has more antibacterial activity.

TABLE 7: ZONE OF INHIBITION (MM) BY TEST AROMATIC OILS ON MICROORGANISMS ON MUELLER-HINTON AGAR MEDIUM (INCUBATION TEMP.: 37ºC; PERIOD: 24 H; VOLUME OF OIL IN EACH WELL = 10 µL)

Roasting Conditions	*B.subtilis*	*S.aureus*	*E.coli*	*Enterobacter aerogenes*
Control	18.35±0.04^{a}	14.14±0.01^{a}	19.58±0.06^{a}	11.23±0.02^{a}
80 °C				
10 min	20.14±0.03^{b}	17.23±0.02^{bd}	20.41±0.05^{b}	13.64±0.04^{b}
20 min	22.67±0.02^{c}	18.38±0.60^{c}	23.42±0.08^{c}	14.88±0.06^{c}
30 min	19.85±0.04^{d}	17.05±0.005^{d}	20.06±0.05^{d}	12.63±0.04^{d}
100 °C				
10 min	24.43±0.02^{e}	20.23±0.02^{eg}	24.65±0.03^{e}	15.50±0.09^{e}
20 min	25.86±0.02^{f}	22.56±0.03^{fi}	26.71±0.06^{f}	16.65±0.02^{f}
30 min	24.03±0.01^{g}	19.94±0.06^{g}	24.14±0.04^{g}	15.06±0.05^{g}
180 °C				
10 min	26.80±0.06^{h}	24.13±0.02^{h}	26.90±0.02^{h}	18.77±0.01^{h}
20 min	25.03±0.02^{i}	22.88±0.04^{ij}	25.24±0.02^{i}	17.32±0.02^{i}
30 min	25.23±0.02^{j}	23.11±0.03^{j}	26.12±0.01^{j}	17.96±0.09^{j}

Values are in terms of mean ± SD after triplicate analysis. Different letter (a,b,c,d,e,f,g,h,i,j) in a coloum represents significant differences ($P<0.05$)

CONCLUSION: This study showed that the temperature (80 to 180 ºC) and the duration of roasting (10 min to 30 min respectively) had little effect on the physicochemical characteristics of the Cinnamon bark oil.

In the same way, the composition was changed by roasting whatever the temperature and the time used. These findings make it possible to conclude that roasting at temperatures of 80 °C for 20 min, 100 °C for 20 min and 180 °C for 10min will allow the production of organoleptic characteristics without losing the nutritional value and the oxidative stability of the oil. Roasting should be performed in a lidded pan to preserve the antioxidant activity of the spices.

AUTHOR CONTRİBUTİONS: Moumita Dev is responsible for carrying out the experimental work alone and in consultation with the other authors who are the faculty and involved in this kind of research study.

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