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Quality profile and antioxidant activity of cinnamon bark powder at varying temperature

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The true cinnamon, *Cinnamomum verum* syn. *C. zeylanicum,* is a native of Sri Lanka and South India. It is a popular spice used by several cultural traditions for centuries. *In vitro* and *in vivo* evidences indicate that cinnamon possesses multiple health benefits, mainly in relation to hypoglycaemic activity. The therapeutic potential of cinnamon is attributed to its antimicrobial, antifungal, antiviral, antioxidant, antitumor, blood pressure lowering, hypolipidemic and gastro-protective properties (Bandara *et al.,* 2012; Gruenwald *et al*., 2010). Anderson *et al*. (2004) and Jayaprakasha *et al*. (2006) isolated phenolic constituents from fruits of *C. zeylanicum* and found free radical scavenging potential and insulin-like biological activity. Marongiu *et al*. (2007) reported 19 compounds in the bark oil of *C. zeylanicum*, extracted by supercritical fluid extraction. Gruenwald *et al.* (2010) made an extensive review on cinnamon and health. Studies have demonstrated its insulin mimetic activity to regulate the cellular glucose metabolism and that it can act as an adjunct in the treatment of type 2 diabetes mellitus. Allen *et al*. (2013) reported that in a dose-dependent meta-analysis of randomized controlled trials (RCTs), cinnamon reduced fasting plasma glucose, total cholesterol, triglycerides and increased HDL-C levels. Mishra *et al.* (2010) reported that volatile oil from cinnamon contains more than 98 per cent cinnamaldehyde which can offer dose-dependent protection against alloxan-induced renal damage, with reduction in fasting blood glucose level.

Dried cinnamon bark contains volatile oil, fixed oil, tannin, resin, proteins, cellulose, pentosans, mucilage, starch, calcium oxalate and mineral elements. The bark oil, bark oleoresin and leaf oil are important value added products which are used in food and pharmaceutical industries. Volatile oil content in cinnamon bark varies from 0.4 to 2.8 per cent. Generally, stem bark oil of a commercial cinnamon bark contains 75 per cent cinnamaldehdyde, 5 per cent cinnamyl acetate, 3.3 per cent caryophyllene, 2.4 per cent linalool and 2.2 per cent eugenol (Leela, 2008). Cinnamon bark oleoresin, obtained by solvent extraction, is mainly used for flavouring food products such as cakes and confectionary. High phenolic content of cinnamon contribute to its potential antioxidant property (Nagendra Prasad *et al*., 2009). The bark constituents vary considerably based on location, age of the tree, climatic condition, season, time of harvest and duration of storage. Cinnamon bark is generally powdered and stored in polypropylene covers under ambient temperature (25-35 ^{o}C). No study has been conducted to evaluate the impact of high temperature on the flavouring constituents. Volatile oil by steam distillation and oleoresin by solvent extraction are items of commercial importance from cinnamon powder. The present study is an attempt to find out the effect of exposure of ground cinnamon to varying temperatures of 40 ^{o}C and 50 ^{o}C on the essential oil content, its composition, oleoresin, total phenol and antioxidant activity.

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Table1. Essential oil, oleoresin and phenol content of cinnamon bark stored at 40 °C for 5 days

Days	Essential oil (%)	Oleoresin (%)	Phenol (%)
0	2.6	6.8	1.9
1	2.0	6.6	1.9
2	2.0	6.6	1.9
3	1.7	6.4	1.8
4	1.7	6.4	1.8
5	1.7	6.2	1.8
F	4.69	2.28	1.14
F Critical	3.68	3.68	3.68
Significance (P=0.05)	S	NS	NS

S- Significant; NS- Non-significant

Cinnamon bark from cv Navasree, extracted by adopting established procedures, was sundried to a moisture level of 10 per cent and used for the study. The dried bark was powdered in a pin mill using the 120 mesh sieve. The powder was kept in oven at 40 °C for 5 days in open condition. Another set of powdered sample was exposed to 50 °C and stored in three layered (12 micron) metalized polyester as well as in open condition for 10 days. Samples were drawn daily and analysed for oil, oil constituents, oleoresin, total phenol and antioxidant property. Volatile oil from powdered bark was extracted by hydro-distillation using Clevenger apparatus lighter than water type and quantified as volume by weight percentage (ASTA, 1968). Oleoresin from the powdered sample was separated using acetone by the cold percolation technique and the same was quantified as weight by weight percentage (ASTA, 1968). Total phenol was estimated by the phosphomolybdic acid method described by Sadasivam and Manickam (2008). Antioxidant properties of water, alcohol and petroleum ether extracts of cinnamon bark was estimated by the three standard assays, *viz*., DPPH reducing property, ferric reducing power and phosphomolybdenum activity (Gulcin, 2005; Oyaizu, 1986; Prieto *et al*.,1999; Braca *et al*., 2001). Gas chromatographic analysis of essential oil was conducted using a Perkin Elmer Clarus 500 GC equipped with Turbo chrome software, version 6.3.2.0646 with an oven programme 70 to 210 °C @ 5 °C per minute using Elite 5 column and flame ionization detector. GCMS profile of oil was carried out using Shimadzu 2010 GC coupled with MS QP 2010. The separation was done using RTX-5 column and carrier gas used was helium at one mL min^{-1}. Column programme: 60 °C for 5 min, followed by 60-110 °C @ 5 °C min^{-1}, 110-180 @ 3 °C min^{-1} and 180-220 @ 5 °C min^{-1} and held for 5 min. The data was statistically analyzed using MS Excel single factor ANOVA. Each data point was a mean of three replications and F test was applied and significance was tested at P=0.05 per cent probability.

Table 1 illustrates the oil, oleoresin and total phenol content of cinnamon cv. Navasree bark ground in pin mill and stored at 40 °C for 5 days. Reduction was found in both oil (17%) and marginal reduction in oleoresin (6%) content when exposed

Table 2. Antioxidant activity of cinnamon bark powder stored at 40 °C for 5 days

Days	DPPH IC_{50} (µg mL^{-1})			Phosphomolybdenum (MAAE g^{-1} of extract)			FRAP (MAAE g^{-1} of extract)		
	Alcohol	Water	Petroleum ether	Alcohol	Water	Petroleum ether	Alcohol	Water	Petroleum ether
0	92.6	86.9	15.8	53.8	31.7	1.7	251.8	189.3	6.9
1	92.6	86.7	15.6	53.5	31.6	1.7	251.6	189.3	6.8
2	92.6	86.3	15.5	53.5	31.6	1.6	251.5	189.2	6.8
3	92.4	86.3	15.5	53.3	31.5	1.4	251.4	189.2	6.8
4	92.4	86.2	15.5	53.2	31.3	1.4	251.3	189.2	6.6
5	92.1	86.0	15.4	53.2	31.1	1.4	251.2	189.1	6.6
F	2.95	2.93	0.02	2.46	1.32	0.58	1.37	1.88	0.86
F Critical	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
Significance (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS- Non-significant, MAAE- Molar ascorbic acid equivalence

Table 3. Essential oil, oleoresin and phenol content of cinnamon bark stored at 50 °C for 10 days

Days	Oil (mL 100 g^{-1})		Oleoresin (gm %)		Phenol (packed) (mg GAE g^{-1} of extract)		
	Open	Packed	Open	Packed	Alcohol	Water	Petroleum ether
0	1.60	1.60	7.60	7.60	1.80	1.60	0.24
1	1.13	1.17	7.57	7.73	1.80	1.57	0.23
2	1.17	1.20	7.30	7.43	1.77	1.50	0.23
3	1.07	1.17	7.53	7.33	1.73	1.43	0.23
4	1.00	1.13	7.30	7.20	1.70	1.50	0.24
5	1.00	1.13	7.23	7.20	1.73	1.53	0.23
6	1.07	1.17	7.27	7.20	1.77	1.53	0.25
7	1.03	1.10	7.60	7.83	1.77	1.57	0.23
8	1.03	1.20	7.23	7.33	1.73	1.50	0.23
9	1.07	1.23	7.50	7.50	1.70	1.47	0.24
10	1.03	1.17	7.67	7.37	1.73	1.50	0.23
F	33.87	37.39	0.04	0.53	2.54	0.46	0.93
F Critical	3.31	3.31	3.31	3.31	3.31	3.31	3.31
Significance (P=0.05)	S	S	NS	NS	NS	NS	NS

GAE-Gallic acid equivalence; S-Significant; NS-Non-significant.

Table 4. Essential oil constituents of cinnamon bark (% in oil) ground in pin mill and stored at 50 °C for 10 days (powder kept in packets)

Sl No.	Compound (% in oil)	Days of storage									
		1	2	3	4	5	6	7	8	9	10
1	Benzaldehyde	0.10	0.06	0.10	0.32	0.41	t	0.30	0.30	0.37	1.38
2	α-phellandrene	0.08	0.09	0.02	0.17	0.16	t	t	0.12	t	0.44
3	β-phellandrene	0.75	1.28	0.87	0.39	0.33	1.06	0.08	1.08	t	3.32
4	β-linalool	2.07	3.61	2.06	3.03	1.23	3.47	1.03	2.63	2.36	9.16
5	β-phenylpropionaldehyde	0.68	0.77	0.66	0.69	0.78	0.78	0.76	0.62	0.74	1.92
6	α-terpineol	0.51	0.74	0.47	0.36	0.35	0.74	0.36	0.53	0.65	1.97
7	Cis-cinnamaldehyde	1.26	1.18	1.06	1.44	1.56	1.16	1.75	0.99	1.73	2.81
8	Trans-cinnamaldehyde	75.28	73.75	70.68	73.35	74.05	68.64	77.25	75.46	70.39	74.04
9	Phenyl allyl alcohol	0.26	0.15	0.24	0.39	0.42	t	t	t	t	0.88
10	Eugenol	2.36	2.51	2.30	2.39	2.43	2.93	2.54	2.45	2.50	2.43
11	α-caryophyllene	3.00	2.71	2.73	2.67	1.37	2.77	0.26	2.48	0.99	2.46
12	Cinnamyl acetate	6.60	4.76	8.43	4.25	6.50	5.30	8.32	3.95	4.41	3.28
13	β-caryophyllene	0.69	0.58	0.53	0.52	0.28	0.61	0.08	0.48	-	1.30
14	Methoxycinnamaldehyde	0.86	0.87	1.02	1.41	1.27	1.46	1.49	0.89	1.41	0.75
15	Caryophyllene oxide	0.62	0.54	0.46	0.39	0.14	t	0.27	0.25	0.32	0.49
16	Myristaldehyde	0.82	0.94	1.21	0.94	1.18	1.23	1.70	1.00	1.11	1.70
17	Benzyl benzoate	2.96	4.37	5.74	5.64	6.10	12.94	t	5.72	7.51	3.59

t - Trace

Table 5. Antioxidant activity of cinnamon bark powder stored at 50 °C for 10 days

Days	$DPPHIC_{50}$ ($\mu g\ mL^{-1}$)			Phosphomolybdenum (MAAE g^{-1} of extract)			FRAP (MAAE g^{-1} of extract)		
	Alcohol	Water	Petroleum ether	Alcohol	Water	Petroleum ether	Alcohol	Water	Petroleum ether
0	90.3	82.3	13.1	50.2	28.1	1.3	246.1	185.0	5.8
1	90.6	82.6	13.3	50.5	28.1	1.3	246.3	185.1	5.8
2	90.4	82.3	13.8	50.3	28.4	1.3	246.7	185.5	5.8
3	90.4	82.3	13.5	50.2	28.2	1.2	246.4	185.6	5.8
4	90.4	82.6	13.7	50.3	28.3	1.2	246.5	185.4	5.7
5	90.1	82.5	13.1	50.1	28.6	1.3	246.5	185.1	5.5
6	90.4	82.6	13.7	50.2	28.6	1.5	246.3	185.1	5.5
7	90.7	82.0	13.4	50.2	28.2	1.5	246.1	185.6	5.6
8	90.4	82.3	9.4	50.2	28.1	1.3	246.5	185.4	5.8
9	90.4	82.6	13.5	50.5	28.0	1.2	246.4	185.3	5.8
10	90.3	82.4	13.1	50.6	28.3	1.3	246.3	185.5	5.6
F	0.05	0.13	0.01	2.01	0.89	0.84	1.23	2.75	2.63
F critical	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31
Significance (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS- Non-significant MAAE- Molar ascorbic acid equivalence per g of extract

to higher temperatures. Reduction in oil was found to be statistically significant. Total phenol was estimated in three different extracts *viz.,* alcohol, water and petroleum ether. Effect of temperature on phenol content was non-significant. Table 2 indicates the antioxidant activity of alcohol, water and petroleum ether extracts of cinnamon powder exposed to 40 ^{0}C by three different methods such as the DPPH reducing property, phosphomolybdenum activity and FRP reducing power of cinnamon bark powder stored at 40 °C for 5 days. Effect of temperature on antioxidant activity by different methods was found to be non-significant. The total phenol and the oleoresin present may contribute towards the antioxidant activity. Hence, it is clear that exposure of cinnamon bark powder continuously to 40 ^{0}C for 5 days did not affect its medicinal properties.

Table 3 illustrates essential oil, oleoresin and total phenol content of cinnamon cv. Navasree bark ground in pin mill and stored at 50 °C for 10 days both in open and packed condition. It was found that open condition led to loss of oil to the tune of 36 per cent and packed condition 27 per cent. Oil loss in both open and packed conditions was significant. Exposure to 50 ^{o}C for 10 days did not affect the oleoresin content. As aroma of cinnamon is vital in culinary preparations, exposure to 50 °C in open/packed condition affected aroma critically. Total phenol extracted by three different solvents showed negligible variation. Effect of temperature on phenol was found to be non-significant. Table 4 illustrates the essential oil constituents of cinnamon bark ground in pin mill and stored at 50 °C for 10 days. The major constituents which play key role in the culinary property of cinnamon bark were not affected by the continuous exposure to high temperature. Trans-cinnamaldehyde, eugenol, eugenyl acetate, cinnamyl acetate *etc*. were unaffected even after 10 days. Table 5 illustrates the antioxidant activity as DPPH reducing property, phosphomolybdenum activity and FRP reducing power of cinnamon bark powder stored at 50 °C for 10 days. The antioxidant property remained static even after keeping for 10 days at 50 °C. Effect of temperature on antioxidant activity was non-significant. The presence of total phenol, trans-cinnamaldehyde, eugenol *etc.* may be contributing towards the antioxidant property. Bark of cinnamon varieties Navashree and Nithyasree yield 2.7-2.8 per cent volatile oil with 58-68 per cent cinnamaldehyde content (Krishnamoorthy *et al.,* 1996)

Cinnamon bark and its essential oil are reported to be good preservatives in food due to the antioxidant property of cinnamon. Hydroxy cinnamaldehyde and hydroxy cinnamic acid, the major phenolic compounds present in the cinnamon extract act as scavengers of peroxide radicals and prevent oxidative damages. Many pharmacological reports establish the potential of cinnamaldehyde as an anti-diabetic agent. Hence, the study clearly reveals that cinnamon bark or powder stored at higher temperature may not be ideal for culinary purpose. However, its antioxidant and medicinal properties were intact for a long time.

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