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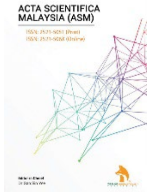

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RESEARCH ARTICLE

EFFECT OF VARIOUS PROCESSING METHODS ON PHYTOCHEMICAL PROPERTIES OF TURMERIC (*CURCUMA LONGA* LINN.) RHIZOME VAR. KAPURKOT HALEDO-1

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ABSTRACT

A study on "Effects of various processing methods on phytochemical properties of turmeric (*Curcuma longa* linn.) rhizome var. kapurkot haledo-1" was conducted from February to March 2021 to evaluate the effects of different processing methods on the functional and physio-chemical properties and phytochemical composition of turmeric rhizomes. The trial was carried out with 3 treatments, i.e., T1=Fresh turmeric rhizomes, T2=Blanched/Oven-parched turmeric powder, and T3=Cooked/Oven-parched turmeric powder), with the former comprising the phytochemical analysis of turmeric. Turmeric essential oils were extracted from the treatments via two methods, viz. hydrodistillation using a Clevenger apparatus and cold percolation. For the powdered samples, both methods were applied to extract essential oils, whereas essential oils from fresh samples were extracted via only hydrodistillation. The experiment was replicated twice for each treatment. Phytochemical analysis revealed Turmerone, Altantone < (Z)-γ->, Turmerone-ar, Zingiberene α and Sesquiphellandrene β as the major bioactive compounds found in the essential oils of turmeric rhizomes. The highest number of bioactive compounds (32) was detected in the essential oils extracted from the fresh samples by hydrodistillation, and the lowest number of bioactive compounds (14) was detected in the essential oils extracted from the blanched and cooked powder samples by cold percolation. The chemical composition of essential oils extracted from fresh rhizomes via hydrodistillation differ completely from that of essential oils extracted from processed rhizomes via different methods.

KEYWORDS

Bioactive compound, Essential oils, Extraction, Rhizome, Turmeric

1. INTRODUCTION

Turmeric *Curcuma longa* Linn. is a plant of the Zingiberaceae family, which belongs to the Zingiberales order of monocots (Nair, 2019). Turmeric is an upright perennial herb with a height of approximately 120 cm however, there are large differences in plant height across types as well as plants cultivated under varied agro-climatic conditions (Ravindran et al., 2007). Leaves grow in tufts, alternating, obliquely erect, or sub-sessile, with long leaf stalks or sheaths producing a pseudostem or aerial shoot. The rhizome is turmeric's subterranean stem and is differentiated into two parts: the core pear-shaped "mother rhizome" and its lateral axillary branches, known as "fingers". Mature mother rhizomes can have 7-12 nodes, and the internodal length ranges from 0.3 to 0.6 cm (Shah and Raju, 1975).

As one of the highly investigated crops, over 100 components have been extracted from turmeric (Prasad and Aggarwal, 2011). The main constituent of the root is a volatile oil, which is a component of turmerone, Turmeric also contains other coloring compounds known as curcuminoids. Curcuminoids encompass curcumin, demethoxycurcumin, 5'-methoxycurcumin, and dihydrocurcumin, which are natural antioxidants (Ruby et al., 1995; Selvam et al., 1995). The criterion turmeric rhizome consists of moisture (>9%), curcumin (5–6.6%), extraneous matter (<0.5% by weight), mold (<3%), and volatile oils (<3.5%). Volatile oils include d-α-phellandrene, d-sabinene, cinol, borneol, zingiberene, and sesquiterpenes (Oshiro et al., 1990). There are different types of sesquiterpenes, such as germacrone; termerone; ar-(+)-, α-, and β-termerones; β-bisabolene; α-curcumene; zingiberene; β-sesquiphellanderene; bisacurone; curcumenone; dehydrocurdione; procurcumadiol; bis-acumol; curcumenol; isoprocurcumenol; epiprocurcumenol; procurcumenol; zedoaronediol; and curlone, many of these are particular to a species. The constituents contributing to the odor of turmeric are turmerone, ar-turmerone, and zingiberene. Rhizomes are found to include four novel polysaccharide-ukonans, stigmasterol, β-sitosterol, cholesterol, and 2-hydroxymethyl anthraquinone (Kapoor, 1990; Kirtikar et al., 1993).

The volatile turmeric oil is derived from dried rhizomes, which contain roughly 5-6% oil, and leaves which comprise about 1.5%. In general, volatile oil is extracted using steam or hydrodistillation, and processing and extraction procedures play a significant role in maximizing oil output, pigments, and their constituents . (Chwmpakam and Parthasarathy, 2008). The percolation method can also be employed to extract essential oils. Similarly, supercritical extraction, which uses carbon dioxide, is also used for the extraction of volatile oils and oleoresin. The characteristic turmeric aroma is imparted by ar-turmerone (Chwmpakam and Parthasarathy, 2008).

Gas chromatography-mass spectrometry (GC-MS) has been widely used to determine the chemical composition of the essential oil obtained from C. longa rhizomes. GC-MS is typically used for sesquiterpenoid analysis alone or in combination with GC-FID for quantitative analysis (Manzan et al., 2003; Stunojevic et al., 2015; Pino et al., 2018).

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Table 1: The major constituents of C. longa essential oil vary depending on the plant part used, its genesis, and the technique of extraction and analysis.

Part of turmeric	Genesis	Method of extraction	Analysis	Yield	Major constituents	References
Powdered rhizome	Nepal	Hydrodistillation Clevenger	GC–MS	3.0%	β-turmerone (17.74%), α-turmeron(8.19%), epi-α-patschutene (7.19%), β–sesquiphellandrene (4.99%), 1,4-dimethyl-2- isobutylbenzene (4.4%)	(Devkota & Rajbhandari, 2016)
Pulverized rhizomes	India	Steam distillation + vacuum distillation	GC–MS	1.6–46.6%	Turmerones, l-zingiberene, β–sesquiphellandrene, ar-curcumene	(Matsumura, et al., 2016)
Rhizomes	Pakistan	Hydrodistillation	GC–MS	0.673%	ar-turmerone (25.3%), α-turmerone (18.3%) and curlone (12.5%)	(Naz, Ilyas, Parveen, & Javed, 2010)
Dried rhizomes	Brazil	Extraction with volatile solvents	GC–MS and GC-FID	5.49%	α-turmerone and β –turmerone (~8.7%), ar-turmerone (~3.6%)	(Stanojevic, Stanojevic, Cvetkovic, & Danilovic, 2015)
Dried rhizomes	Nigeria	Hydrodistillation Clevenger	GC–MS	1.33% w/w	ar-turmerone (44.4%),α-turmerone (20.8%), β–turmerone (26.5%)	((Ajaiyeoba, et al., 2008)
Cured rhizomes	India	Hydrodistillation Clevenger	GC–MS	4.45 ± 0.37%	ar-turmerone (28.3%),α-turmerone (24.8%), β–turmerone (21.1%)	(Monton, Luprasong, & Charoenchai, 2019)

2. Materials and Methodology

The study was conducted at the research facility of the Center for Biotechnology, Agriculture and Forestry University, Chitwan; Department of Plant Resources, Kathmandu; Nepal Academy of Science and Technology, Kathmandu; and Department of Food Technology and Quality Control, Kathmandu, from February to March 2021. The experiment's supplies were turmeric rhizomes of the variety Kapurkot haledo-1. The rhizomes were collected from a local grower of Bheriganga municipality, Surkhet. Commercially matured rhizomes from a single source were harvested and transported to the research sites with careful handling. The experiment was conducted with the following treatments:

Treatment 1: Fresh turmeric rhizomes (washed, peeled and grated)

Treatment 2: Blanched (100°C for 10 min) + oven-dried (40°C for 24 h) turmeric powder

Treatment 3: Cooked (1 h) + oven-dried (40°C for 24 h) turmeric powder

Turmeric essential oils were extracted from the treatments via two different methods, viz; hydrodistillation using a Clevenger apparatus and cold percolation. For the powdered samples, both methods were used to extract ethereal oils, whereas essential oils from unprocessed samples were extracted via only hydrodistillation. The experiment was replicated twice for each treatment. Chemical analysis of the essential oils was undertaken via gas chromatography-mass spectrometry (GC–MS). Analytical gas chromatography-mass spectrometry data were recorded on an Agilent 7890A GC–Agilent 5975C inert MSD with a triple-axis detector using an Agilent 19091 s–433 (30 m × 250 μm ×0.25 μm) column. The oven temperature program was maintained at 32°C and gradually increased to 320°C. The apparatus was run at 32°C for 5 min at the rate of 5°Cmin^{-1} up to 230°C with a holding time of 15 minutes. The entire run duration was 59.6 minutes. The temperature of injection was maintained at 230°C, with a volume of 2 μl. Helium was used as the carrier gas, with a flow rate of 1 mL min^{-1}. The MS apparatus was operated in electron impact mode with a 70 eV ionization energy, coupled to GC-MS real-time software, and analyzed after each run. To identify the chemicals, raw GC-MS data was processed and compared to reference libraries. The essential oil samples were injected twice to ensure that the data was reproducible, and the results were expressed as means.

3. Results

A. Bioactive Compounds Detected Via GC–MS Analysis

Chemical characterization via GC–MS revealed that the greatest number of bioactive compounds, i.e., 32, were detected in the ethereal oils derived from the fresh samples by hydrodistillation. This was followed by 18 constituents detected in the ethereal oils extracted from the blanched powder samples by hydrodistillation. Similarly, 16 bioactive compounds were recorded in essential oils derived from cooked powder samples by hydrodistillation. The lowest number of bioactive compounds, i.e., 14, was detected in the essential oils extracted from the blanched and cooked powder samples by cold percolation.

Important bioactive compounds of turmeric ethereal oils identified from various processing and extraction methods via GC–MS are shown in Table 2. The top 15 constituents, based on their contribution to the percentage chemical composition, were tabulated. Turmerone, identified from essential oils of blanched samples by cold percolation, was observed to have the highest composition, i.e., 26.24%. The same compound was observed in 22.13% of the essential oils of cooked powder samples extracted by cold percolation. The tallantones <(Z)-γ-> and turmerone followed turmerone, with the highest contents of 19.46% and 14.58%, respectively, in the essential oils extracted from fresh turmeric samples by hydrodistillation. Curlone (12.70%) was the only compound present in the ethereal oils extracted from the powder turmeric samples by the cold percolation method. Caryophyllene <14-OH-(Z)-> and phthalic acid were the compounds present in the lowest quantities in the turmeric essential oils.

Table 2: Major chemical constituents of ethereal oil identified from different processing and extraction methods via GC–MS.

Compounds identified	Composition (%)				
	Fresh_HD	BOD_HD	BOD_CP	COD_HD	COD_CP
Turmerone	—	—	26.24	—	22.13
Altantone <(Z)-γ->	19.46	14.66	9.18	12.28	8.86
Turmerone ar	14.58	10.17	8.86	8.81	7.11
Curlone	—	—	12.70	—	12.18
Altantone <(E)-γ->	12.09	8.06	7.09	8.09	6.96
Zingiberene α	9.13	6.12	3.11	4.11	3.18
Sesquiphellandrene β	7.64	3.14	2.08	3.19	1.99
Terpinolene	4.15	2.11	2.12	1.91	1.92
Caryophyllene <(E)->	4.05	2.09	2.11	1.86	1.91
Curcumene α	4.02	2.08	1.1	1.65	1.19
3,7-cyclodecadien-1-one	—	—	3.13	2.12	4.19
Eucalyptol	2.26	0.91	0.96	1.08	0.85
Bisabolene β	2.06	—	—	1.06	—
Caryophyllene <14-OH-(Z)->	1.75	—	—	1.11	—
Phthalic acid	—	1.10	1.20	—	0.92

Note: Fresh_HD = Fresh samples + Hydrodistillation, BOD_HD = Blanched

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samples + Hydrodistillation, BOD_CP = Blanched samples + Cold percolation, COD_HD = Cooked samples + Hydrodistillation, COD_CP = Cooked samples + Cold percolation.

B. Relationships Among Various Processing And Extraction Methods

Figure 1. shows the cluster dendrogram depicting the relationships among various processing and extraction methods based on the chemical constituents of the ethereal oils. The figure shows that the chemical composition of the essential oils extracted from fresh rhizomes differed completely from that of the essential oils extracted from processed rhizomes via different methods. The chemical compositions of the ethereal oils derived from the blanched and cooked turmeric samples by the cold percolation method were similar, whereas the chemical compositions of the ethereal oils derived from the blanched and cooked turmeric samples by hydrodistillation were different.

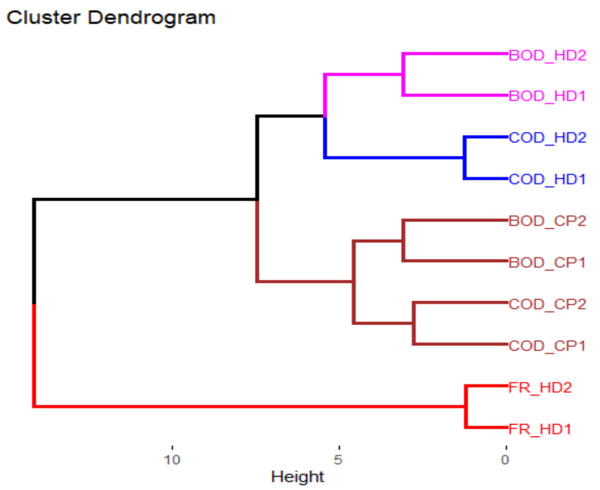

Figure 1: Cluster dendrogram showing relationships among various processing and extraction methods based on the chemical composition of ethereal oils.

Note: Fresh_HD1 = Fresh samples + Hydrodistillation from replication 1,

Fresh_HD2 = Fresh samples + Hydrodistillation from replication 2,

BOD_HD1 = Blanched samples + Hydrodistillation from replication 1,

BOD_HD2 = Blanched samples + Hydrodistillation from replication 2,

BOD_CP1 = Blanched samples + Cold percolation from replication 1,

BOD_CP2 = Blanched samples + Cold percolation from replication 2,

COD_HD1 = Cooked samples + Hydrodistillation from replication 1,

COD_HD2 = Cooked samples + Hydrodistillation from replication 2,

COD_CP1 = Cooked samples + Cold percolation from replication 1,

COD_CP2 = Cooked samples + Cold percolation from replication 2.

4. Discussion

Quality and amount of volatile oils are generally affected by the drying method (Asekun et al., 2007). Dried rhizome oil lacks the majority of the monoterpene hydrocarbons seen in fresh rhizome oil (Kutti Gounder and Lingamallu, 2012). The monoterpenes' low boiling point and high volatility resulted in their loss throughout processing procedures such as grating, drying, and grinding of the rhizome (Díaz-Maroto et al., 2002). In the present study, most of the major compounds present in the fresh rhizome oil were retained in powdered form, whereas the minor compounds present were lost. The results revealed that aromatic turmerone had a lower percentage in the dried rhizome. This could be attributed to the rearrangement and oxidation of the less stable alpha-turmerone into the most stable aromatic-turmerone additionally, the lower number of compounds in the essential oils extracted from turmeric powder can be attributed to the loss of oil components during the heat processing period (Kuttigounder and Rao, 2012).

Several studies have reported the chemical composition of *C. longa* essential oils. Devkota and Rajbhandari (2016) reported 67 compounds in turmeric samples collected from different locations, of which 15 monoterpenes (5.58%), 43 sesquiterpenes (84.37%) and 10 nonterpenic components (8.64%) were recorded. The rhizome oil of *C. longa* from Brazil mainly contains ar turmerone (33.2%), α turmerone (23.5%), and ß turmerone (22.7%) (Braga et al., 2003). Ethereal oils extracted from the rhizome samples of Bangladesh, ar-turmerone (27.78%), tumerone (17.16%), and culone (13.82%) are the major components (Chowdhury et al., 2008). Among the samples from the lower Himalayan region of northern India, α-turmerone (44.1%), ß-turmerone (18.5%), and ar-turmerone (5.4%) were the main constituents (Raina et al., 2005). Similarly, ar-turmerone (45.8%) and zerumbone (3.5%) were the major components in the samples collected from Malaysia (Jantana et al., 1999). In contrast with the above findings, Usman et al., (2009), in their study conducted in Nigeria, reported bisabolene (13.9%), trans-ocimene (9.8%), myrcene (7.6%), 1,8-cineole (6.9%), thujene (6.7%) and thymol (6.4%) as the major components of turmeric essential oils. As shown in the preceding investigations, the chemical compositions of volatile oils extracted from rhizomes grown in various geographic regions and meteorological conditions varied significantly. The chemical makeup of turmeric essential oils is dependent on the genotype, field circumstances, and postharvest processing of the rhizomes (Cousins et al., 2007).

5. Conclusion

Phytochemical analysis revealed that Turmerone, Altantone <(Z)-γ->, Turmerone ar, Zingiberene-α and Sesquiphellandrene-β are important components present in the turmeric rhizome of the variety Kapurkot haledo-1. Most of the important components found in fresh rhizome oil are kept in powdered form, while the lesser chemicals are lost. The chemical compositions of the essential oils extracted from fresh rhizomes differ completely from those extracted from processed rhizomes via different methods.

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