Berhan International Research Journal of Science and Humanities (BIRJSH), 2021, 5(1), 17-32

Journal homepage: www.journals.dbu.et *ISSN: 2414-2794*

Extraction and characterization of aromatic essential oils for natural perfume formulation

Tilahun Gisila Abebe [1*], Amare Ayalew Abebe [2], Minbale Gashu Tadesse [2], Samuel Begashawu Mandefro [1]

[1]*Debre Berhan University, College of Engineering, Department of Chemical Engineering*

[2]*Debre Berhan University, College of Natural and Computational Science, Department of Chemistry*

Abstract

The purpose of this study was to extract essential oils from selected medicinal and aromatic plant leaves and flowers for natural perfume formulation. Fragrant essential oils were extracted from *Lavandula angustifolia* (leaves and flowers) (1.30%), *Cymbopogon martini* (leaves) (1.04%), *Rosmarinus officinalis* (leaves) (0.91%), *Cymbopogon nardus* (leaves) (0.83%), *Juniperus procera* (fruit) (2.3 %), and *Thymus schimperi* (leaves) (1.17%) by using steam distillation, whereas resin was obtained from *Boswellia papyrifera* (5%) using Soxhlet extractor (hexane), both extractants were analyzed by GC-MS. Camphor (21.19%), α-Thujene (16.29%), endo-borneol (14.08%), β-pinene (9.22%) and α-pinene (7.07%) in *L. angustifolia*; geraniol (40.89%), β-Myrcene (9.34%), 2,4,6,octatriene,2,6-dimethyl (8.20%), β–ocimene (5.93%) in *C. martini*; α- pinene (38%), eucalyptol (27.76%), caryophyllene (7.37%) and bornanone (7.27%) in *R. officinalis*; α-pinene (85.68%) and α-Sabinene (13%) in *J. procera*; citronellal (38.21%), citronellol (23.16%) and 3-carene (14.26%) of *C. nardus* and Incensole (53.%) and Pulespenone (46.95%) from resins of *B. papyrifera* were found as major components. Local perfumes were formulated using different proportions of fragrance essential oils and ethyl alcohol as a solvent. The main chemical compounds that are found in fragrant essential oils such as linalool, geraniol, citronellol, α-pinene, β-pinene, citronellal and eucalyptol determined the perfume scent. The panelist hedonic test showed that the first chosen perfume containing, *L. angustifolia* as top note; *C. martini* as a middle note and *B. papyrifera* as a base note and the second one containing *C. nardus* as top note; *R. officinalis* as a middle note and *B. papyrifera* as base note. Generally, the selected essential oils could be used as a substitute for the production of natural perfume for Air freshener or body splash after further toxicological tests are performed on the product.

Keywords: Natural perfume**,** Essential oil, Formulation, Panelist

*Corresponding author email: *tile2224@gmail.com*

Article information: Received 25 March 2021; Revised September 2021; Accepted 18 Octoberr 2021

Introduction

The natural fragrance materials (animal or plant origin) and synthetic scented molecules are employed in perfumery and named as aroma chemicals (Surburg and Panten, 2006). The amount and purity of essential oils extracted from the completely aromatic plant or a part of it depend on the method of extraction and usually, steam distillation is employed. Perfume is a mixture of such sweet-smelling essential oils and other aroma compounds, fixatives and solvents to give the human body, objects and spaces a pleasant smell. Since the beginning of recorded history, humans have tried to mask or improve their odor by using perfume which emulates nature's pleasant smells (Kyla *et al*., 2006). Perfumes are formulated by adding essential oils (concentrates) incorporated with ethanol and water and some fixatives (Al Bayati, 2016). Although there is no single "correct" technique for the formulation of a perfume, there are general guidelines as to how a perfume can be constructed from a concept (Sumpena et al. 2019). Eau de perfumes are usually formulated in oils, are normally clear, and generally have an amber colour due to the natural colour of the oils.

The constituents of perfume as a unique mixture are mostly composed of aromatic compounds, alcohol and water. The basics in a perfume, categorized as top, middle and base notes, were designed to give a particular harmony of scents (Vankar Padma, 2004).

Top notes are small light molecules contained in Lemon, Lime, Basil, Bergamot, Cardamom, Clary Sage, Coriander, Eucalyptus, Grapefruit, Junipers, Lavender, Lemongrass, Mandarin, Orange, Pine, Peppermint, Tea Tree, Thyme, etc. and makeup 15-25 % of the fragrance (Vankar Padma, 2004). The middle note compounds form the "heart" of a perfume and act to mask the often-unpleasant initial impression of base notes, which become more pleasant with time and make up of 30-40 % of the total fragrance. Some of the natural fragrances used for the middle note are Cedarwood, Cinnamon, Clove, Geranium, Jasmine, Marjoram, Chamomile, Rose (Sumpena *et al*., 2019; Vankar Padma S, 2004). Base notes or bottom notes comprise of 40-55 % of the total fragrance and tend to be long-lasting. Therefore, this research aimed to select aromatic plants and extract the fragrance essential oils for perfume formulation and evaluate the fragrance level with selected panelists.

Materials and Methods

Research Site, Plant Materials and Extraction Methods

This research was done at Debre Berhan University at Ankober Research Center and Chemistry Department. Fresh (about 1 kg of each) *Cymbopogon nardus*, *Cymbopogon martini*, *Rosmarinus officinalis*, *Thymus schimperi*, *Lavandula angustifolia*, *Juniperus procera* (*berries*), *Foeniculum vulgare* were collected from

Ankober Project Nursery Site, and *Boswellia papyrifera* (1 kg) were purchased from Addis Ababa. The plant materials were identified by a professional botanist working at Debre Berhan University, Department of Biology. The collected plant materials were washed to remove unwanted dust material, crushed into a smaller size to make it easier for the extraction and stored overnight in shade and depend on the plant essential oils were extracted from the samples by steam distillation and Soxhlet extraction. For instance, oleoresin was extracted from *Boswellia papyrifera* by Soxhlet extraction using hexane as a solvent.

The percentage yield was calculated based on the initial mass of a sample using the formula as follows.

$$\%\ \text{Yield} = \frac{\text{Amount of essential oil (g)}}{\text{Amount of raw material used(g)}} x100\%$$

GC-MS Analysis

The chemical components found in essential oils were identified by GC-MS using HP 5890 series GC equipped with a mass selective detector (MSD), HP 5972 series (German) found in Addis Ababa University, Science College. A fused-silica capillarity column (30 m, 0.25 mm, 0.25µm film thickness) with chemically bonded HP-5 MS was used for the GC separation. The initial oven temperature, 50 ^{0}C, was held for 6 min then raised at the rate of 4 ^{0}C/min to 76 ^{0}C, and this was held for 4 min, then raised at the rate of 4 ^{0}C/min to 190 ^{0}C, then raised at the rate of 30 ^{0}C/min to 270 ºC, this was held for 6 min. Other operating conditions were as follows: carrier gas, He (99.999 %), with a flow rate of 1 ml/min; injector temperature, 260 ^{0}C; split ratio, 20:1. Mass spectra were recorded at 70 eV and the mass range was from m/z 40 to 400 amu, ion source temperature 230 ^{0}C and quadruple temperature 150 ^{0}C. The constituents were identified by comparison of their mass spectra with those of NIST08 library data for the GC-MS system. The results were further confirmed by comparison of their retention time of the compounds with that of literature data

Classification of essential oils used in perfume formulation and Sensory analysis

The essential oils extracted from flowers and leaves were separately blended, as classified below, according to a formula given elsewhere (Vankar Padma, 2004). Ethanol (95 % ABV) was added to the mixture to homogenize dissolved ingredients.

The identification of more than three perfumes is difficult and no analytical tool can completely replace the human olfactory system for fragrance classification (Jarboui *et al.*, 2020). The prepared perfumes poured into black-brown bottles were placed in the dark area until the hedonic test. Twenty-one panelists performed the rating of the formulated perfume the odor of the formulated perfume samples using checklists. The assessment criterion of the perfume formulation test was rated as shown in Table 2.

Table 1. Essential oil classification based on Fragrance notes and perfume preparation

No.	Top Notes	Middle Notes	Base Note
1	*L. angustifolia*	*C. martini*	*B. papyrifera*
2	*C. nardus*	*R. officinalis*	*B. papyrifera*
3	*J. Procera*	*T. schimperi*	*B. papyrifera*
4	*L. angustifolia* and *J. Procera*	*C. martini*, *R. officinalis*	*B. papyrifera*
5	*L. angustifolia* and *J. Procera*	*C. martini*, and *F. vulgare*	*B. papyrifera*
6	*L. angustifolia* and *J. Procera*	*C. martini* and *T. schimperi*	*B. papyrifera*
7	*L. angustifolia*, *C. nardus*	*C. martini*, and *F. vulgare*	*B. papyrifera*
8	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *T. schimperi*	*B. papyrifera*
9	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *F. vulgare*	*B. papyrifera*
10	*L. angustifolia*, *J. Procera*, *C. nardus*	*C. martini*, *T. schimperi*	*B. papyrifera*
11	*L. angustifolia*	*C. Martini*	*B. papyrifera*
12	*C. nardus*	*R. officinalis*	*B. papyrifera*
13	J. procera	*T. schimperi*	*B. papyrifera*
14	*L. angustifolia* and *J. Procera*	*C. martini*, *R. officinalis*	*B. papyrifera*
15	*L. angustifolia* and *J. Procera*	*C. martini, and F. vulgare*	*B. papyrifera*
16	*L. angustifolia* and *J. Procera*	*C. martini and T. schimperi*	*B. papyrifera*
17	*L. angustifolia*, *C. nardus*	*C. martini, and F. vulgare*	*B. papyrifera*
18	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *T. schimperi*	*B. papyrifera*
19	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *F. vulgare*	*B. papyrifera*
20	*L. angustifolia*, *J. Procera*, *C. nardus*	*C. martini*, *T. schimperi*	*B. papyrifera*
21	*L. angustifolia*	*C. Martini*	*B. papyrifera*
22	*C. nardus*	*R. officinalis*	*B. papyrifera*
23	J. procera	*T. schimperi*	*B. papyrifera*
24	*L. angustifolia* and *J. Procera*	*C. martini*, *R. officinalis*	*B. papyrifera*
25	*L. angustifolia* and *J. Procera*	*C. martini, and F. vulgare*	*B. papyrifera*
26	*L. angustifolia* and *J. Procera*	*C. martini and T. schimperi*	*B. papyrifera*
27	*L. angustifolia*, *C. nardus*	*C. martini, and F. vulgare*	*B. papyrifera*
28	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *T. schimperi*	*B. papyrifera*
29	*L. angustifolia*, *C. nardus* and *J. Procera*	*C. martini*, *F. vulgare*	*B. papyrifera*
30	*L. angustifolia*, *J. Procera*, *C. nardus*	*C. martini*, *T. schimperi*	*B. papyrifera*

Table 2. Perfume fragrance level criteria for panelist evaluation.

S.N	Criteria	Score
1	Like very much	5
2	Like moderately	4
3	Like slightly	3
4	Neither like nor dislike (Less fragrant)	2
5	Dislike strongly	1

Results and Discussion

Essential oil yield

The essential oil content of *Lavandula angustifolia*, *Cymbopogon martini*, *Rosmarinus officinalis*, *Cymbopogon nardus*, *Boswellia papyrifera*, *Juniperus procera and Thymus schimperi* is given in Table 3. Based on the fresh leaves mass the essential oil content of *Lavandula angustifolia* was 1.3 % by mass. Sarkic and Stappen (2018) reported that *Lavandula angustifolia* essential oil is a clear, colourless to pale yellow liquid with a characteristic odor that is extracted by steam distillation from its flowering tops. The investigation done by Kara and Baydar, (2013), who compared four cultivars of *Lavandula angustifolia*, showed that the content of essential oil oscillated from 0.35 to 2.0%. The lower content of essential oil (0.71–1.30 %) in the dried lavender flowers. Seidler *et al.* (2014) reported 3% from dry *Lavandula angustifolia* flowers. The essential oil content of *Cymbopogon martini* leaves was found 0.82 % on wet leaves mass basis which is lower than the value (1.0%-1.4 %) reported, by *Padalia et al.* (2011). Clear and intense yellow-brownish, pleasant smell essential oil (0.91 % yield) was obtained from steam distillation of fresh *Rosmarinus officinalis*. An oil yield of 1.1% (w/w) with hydrodistilation was reported by Asressu and Tesema (2014).

Steam distilled *Juniper Procera* berries gave an essential oil yield of 2.3 % on a partially dry mass basis. The essential oil content of *Cymbopogon nardus* leaves was found to be 0.636 % from fresh leaves. Lower essential oil (0.5%) was obtained from fresh leaves of *Cymbopogon nardus* with steam distillation for three hours (Wibowo *et al*., 2018). Jawonisi, (2018) reported 1.03 % oil yield and a maximum yield of 1.37 % (w/w) was reported based on a dry weight basis and the specific gravity was 0.8960, indicating a lower density of oil when compared with water. This was further confirmed by its boiling point (74^{o}C) indicating its volatile nature. From the steam distillation of fresh *Thymus schimperi* leaves transparent, yellow or reddish-brown pleasant essential oil (1.17 (w/w) % was obtained. According to Marzec *et al*. (2010) the mean essential oil yield of *Thymus schimperi* was ranged from

1.12% wet leaves to 2.99% on the weight of the air-dried leaves. The oil yield of *Boswellia papyrifera* was found 5%. According to (Al-yasiry and Kiczorowska 2016), *Boswellia papyrifera* resin contains about 5-9% essential oil, 65-85% alcohol-soluble resin, and the remaining 21-22% is water-soluble gum (polysaccharidic fraction and polymeric substances).

Table 3. The essential oil content of selected aromatic plants.

Plant material	Obtained Value (%)	Literatures Value (%)	Literature references
Lavandula angustifolia	1.3	0.35-2	(Kara and Baydar 2013)
Cymbopogon martini	1.04	1-1.4	(Padalia *et al*., 2011)
Rosmarinus officinalis	0.91	1.1	(Asressu and Tesema, 2014)
Juniperus procera	2.3	-	-------
Cymbopogon nardus	0.83	1.03	(Jawonisi, 2018)
Thymus schimperi	1.17	1.12-2.99	(Marzec *et al*., 2010.)
Boswellia papyrifera (oil)	5	5-9	(Al-yasiry and Kiczorowska, 2016)

Chemical composition of extracted essential oils

Comparative analysis of chemical composition of lavandula angustifolia essential oil

Table 4 shows the chemical compounds found in a steam distilled fraction of *Lavandula angustifolia* flower. Camphor (21.19 %), α-Thujene (16.29 %), endo-borneol (14.08 %), β-pinene (9.22 %) and α-pinene (7.07 %) were the components in the first line. The retention indexes of the identified fragrance compounds are included (Babushok *et al.*, 2011; Babushok and Zenkevich 2009; Goodner 2008). According to Seidler et *al*., (2014) the chemical components of lavender flowers essential oil includes linalyl acetate (40 %), linalool (30 %), limonene, α-ocymene, 1,8-cineole, camphor, α-terpineol, borneol, but also phenolic acids (rosmarinic acid), ursolic acid, cumarins (umbelliferone, herniarin) flavonoids and sterols. (Saeidnia et al., 2012), evaluated the aroma profile of lavender oil cultivated in Teheran reported that the main compounds of lavender essential oil were linalool (31.0 %), linalyl acetate (18.2 %) and lavadulyl acetate (10.7 %). According to Stashenko (2008) linalool is found in the essential oils of over

200 plant species, belonging to different families showing linalool and its ester form, linalyl acetate as lavender oil constituents. Krzyzaniak (2006) reported that linalool is a commonly used ingredient being a component of many perfumes top notes and being found in 60–90 % of cosmetic products. Essential oil and extracts derived from the lavender flower are commonly used as cosmetics, fragrance industry, perfumes and hygiene products.

Table 4. Chemical composition of *Lavandula angustifolia* essential oil.

Compounds	RT (min)	RI (Cald)	RI (Lit)	Composition (%)
Camphor	13.919	1118	1126	21.19
α-Thujene	9.221	901	905	16.29
endo-Borneol	14.816	1134	1152	14.08
1,8-Cineole	9.485	1015	1019	10.00
β-pinene	7.376	957	962	9.22
α-pinene	6.070	910	912	7.07
β-Myrcene	7.837	970	975	3.62
α-Terpeneol	15.861	1160	1163	3.48
β-Linalool	11.990	1075	1086	2.50
β-ocimene	9.583	1020	1022	1.93
β-phellandrene	7.273	1001	1005	1.82
Total components identified				95.63

Comparative chemical composition of cymbopogon martini essential oil

Table 5 shows that the compounds found in the leaf essential oil isolated from *Cymbopogon martini* were determined by GC-MS. Its analysis showed geraniol (40.89 %) as a major component which is supported by Mohamed Yousif, (2016) (67-85 %). Cyclofenchene (13.91 %), β–myrcene (9.34 %), 2,4,6,octatriene,2,6 dimethyl (8.20 %), β–ocimene (5.93 %), and a minor amount of hexadecanoic acid, bisabolone, 11-octa decenoic acid, methyl stearate, 4- undeccanone, citral, citronellol, caryophyllene were also identified. The retention indexes of the identified fragrance compounds are included (Babushok *et al*., 2011; Babushok and Zenkevich 2009; Goodner 2008). Geraniol is a naturally occurring terpenoid found in plants, is often used as a fragrance or ingredient in cosmetics (Baker and Grant, 2016) and perfumery raw material (Randriamiharisoa and Gaydou, 2019, Eihab . O and Ahmed M, 2016).

Table 5. Chemical composition of *Cymbopogon martini* leaf essential oil.

Compound	RT	RI (Cald)	RI (Lit)	Composition (%)
Geraniol	11.3352	1218	1230	40.89
Cyclofenchene	12.5382	883	896	13.91
β-Myrcene	6.196	0968	0975	9.34
2,6-dimethyl-2,4,6-octatriene	8.5281	1140	1143	8.20
β–ocimene	7.1391	1015	1022	5.93
Hexadecanoic acid	18.975	1965	1971	5.30
Bisabolone	17.8362	1687	1701	3.93
11- Octa decenoic acid	22.0138	2057	2089	3.48
Methyl stearate	22.2712	2122	2135	3.18
4-Undecanone	11.182	1198	1208	2.3
Citral	11.7896	1120	1240	1.43
Citronellol	10.9065	1207	1211	1.15
Caryophyllene	12.636	1375	1396	0.96
Total components identified				99.9

Comparative chemical composition of rosmarinus officinalis oil

Table 6 shows the chemical composition of *Rosmarinus officinalis* leaf essential oil identified by GC-MS which indicated α-pinene (38%), eucalyptol (27.76%), caryophyllene (7.37%), bornanone (7.27%) as major and β–pinene, D-limonene, endo-borneol, camphor, Cyclofenchene, 1,3,3-trimethyl, α.-terpineol, Verbenone-(-), humulene as minor components. The retention indexes of the identified fragrance compounds are included (Babushok et al., 2011; Goodner 2008).Sarkic and Stappen, (2018) reported that the main chemical compounds in rosemary essential oil are eucalyptol (19.4%) and α-pinene (14.7%). Camphor (9.5%), bornyl acetate (9.1%), camphene (6.9%), β-pinene (6.7%), β-myrcene (5.8%), limonene (5.2%) and borneol (5.0%) are also found in the oil.

According to Porte et al., (2019) the major constituents of the oil were camphor (26.0%), 1,8-cineole (22.1%), myrcene (12.4%) and α-pinene (11.5%). Ayoob Iram (2018) reported that the major compounds of the oil identified are α-pinene (16.33%), 1, 8-cineole (14.33%), camphor (22.01%), camphene (9.28%), β-pinene (5.97%), β-phellandrene (5.19%), bornyl acetate (4.59%), myrcene (4.31%), borneol (3.35%), terpinen-4-ol (1.11%), α-terpineol (1.03%), verbenone (1.39%), γ-terpinene (1.04%), linalool (1.16%) and β-caryophyllene (2.88%).

Table 6. The Chemical composition of *Rosmarinus officinalis leaf essential* oil.

Name	RT	RI (Cald)	RI (Lit)	Content (%)
α- pinene	5.0921	0909	0912	38
1,8-cineol	7.0507	1012	1019	27.76
β-Caryophyllene	12.6348	1371	1396	7.37
α-Bornanone	9.8598	1138	1141	7.27
β–Pinene	5.921	0958	0962	4.23
D-Limonene	6.7214	1011	1014	3.82
endo-Borneol	10.2057	1131	1152	3.46
Camphor	11.3342	1145	1126	2.31
Cyclofenchene	8.8186	880	888	1.79
α-Terpineol	10.3652	1157	1163	1.57
Verbenone-(-)	11.3804	1191	1206	1.52
α-Humulene	13.1316	1425	1430	0.9
Total components identified				99.1

Table 7. Chemical composition of *Juniperus procera* berries essential oil.

Compound	RT	RI (Cald)	RI (Lit)	Composition (%)
α.-Pinene	5.0974	0908	0912	85.68
α-Sabinene	5.9382	0965	0971	13.03
1,3,8-para-Menthatriene	9.7879	1106	1111	1.28
Total components identified				99.99

The major constituents reported are mostly monoterpenes, like α-pinene, 1,8-cineole and camphor with variable amounts of camphene, myrcene, limonene, borneol, verbenone, bornyl acetate. The difference in the chemical composition of the essential oil depends upon environmental conditions, location/elevation, harvesting period, and storage conditions (Ayoob, 2018).

Comparative chemical composition of juniperus procera berries essential oil

The major chemical composition of Juniperus procera berries essential oil was **α**-pinene (85.68%), α-Sabinene (13%) and 1,3,8-para-Menthatriene (1.28) (Table 7). The leaf essential oil of J. procera is dominated by α-pinene (22.3%), 3-carene (18.7%), trans-totarol (8.9%) and abietadiene (7.8%) as well as moderate levels (2–4%) of elemol, α-eudesmol, myrcene, β-phellandrene, β-pinene and terpinolene (Adams 2020). Liorens molina *et al.* (2016) reported that the essential oil composition of the berries is dominated by α-pinene (55.7-65.0 %) and myrcene (16.6-22.6 %). The retention indexes of the identified fragrance compounds are included (Babushok, *et al*., 2011; Babushok and Zenkevich 2009; Goodner 2008). According to Salamon, (2016) juniper essential oil, in particular, is high in α–pinene, β – myrcene, β– caryophylene and terpinen-4-ol, which have very advantageous aromatherapeutic properties.

Comparative chemical composition of cymbopogon nardus essential oil

Table 8 shows the chemical components of *Cymbopogon nardus* essential oil identified by GC/MS. In *Cymbopogon nardus* essential oil more than eleven components, viz, citronellal (38.21%), citronellol (23.16%), 3-carene (14.26%), 2,6-octadiene, 2,6-dimethyl (6.75%), D-limonene (4.93%), were found.

According to Wibowo *et al.*, (2018) major constituents of the essential oil were citronella (26,27%), δ-cadinene (6,97%), methyl isoeugenol (5.87%), caryophyllene (5.87%), geranyl butyrate (5.6%), geranyl acetate (4.41%), citronellyl propionate (4.97%). The retention indexes of the identified fragrance compounds are included (Babushok, *et al*., 2011; Babushok and Zenkevich 2009; Goodner 2008). They present at high concentrations in the essential oil and are responsible for perfume scent formulation. Citronellol is a fragrance ingredient used in decorative cosmetics, fine fragrances, shampoos, toilet soaps and other toiletries as well as in noncosmetic products such as household cleaners and detergents (Lapczynski, *et. al*, 2008). δ-3 carene carries a sweet and earthy aroma with piney undertones. It is found in rosemary, basil, bell pepper, cedar, and turpentine. δ-3-carene is used in cosmetics, perfumes.

Table 8. Chemical composition of *Cymbopogon nardus* essential oil

Compounds	RT	RI (Cald)	RI (Lit)	Composition (%)
Citronellal	9.615	1258	1264	38.21
Citronellol	10.902	1207	1211	23.16
δ -3-Carene	11.316	1005	1008	14.26
2,6-Dimethyl 2,4,6-octatriene	12.074	1149	1152	6.75
D-Limonene	6.7257	1012	1014	4.93
δ-Cadinene	13.765	1509	1522	3.60
(+)-3-Carene	12.533	1010	1013	2.60
Guaia-1(10),11-diene	15.101	1460	1488	2.21
β-Elemene, (-)	12.175	1381	1389	2.08
Total components identified				99.99

The scent of citronella oil (*Cymbopogon nardus*) is known to blend well with all citrus essential oils, such as lemon and bergamot, as well as with cedarwood, clary sage, eucalyptus, geranium, lavender, peppermint, pine, rosemary, sandalwood, and tea tree essential oils. Citronella essential oil can deodorize and refresh foul body odours by inhibiting the growth of odour-causing bacteria, which makes it an ideal ingredient in natural perfumes, deodorants, body sprays, and bath blends (Yasmina Sultanbawa, 2019).

Comparative chemical composition of thymus schimperi essential oil

Table 9 shows GC–MS analysis result of the *T. schimperi* essential oil where o-thymol (58.21%), γ–terpinene (23.75%), thymol (3.42 %), 3- octanol (5.3%), α-terpinene (3.2%) and p-cymene (2.87%) were quantified. According to Dagne and Bisrat, (1998), it was reported that the essential oil obtained from Addis Ababa was rich in carvacrol (66.2%) and γ-terpinene (13.2%). The retention indexes of the identified fragrance compounds are included (Babushok, *et al*., 2011; Babushok and Zenkevich 2009; Goodner 2008).

Comparative chemical composition of boswellia papyrifera oil

Table 9. Chemical composition of *Thymus schimperi* essential oil.

Compounds	RT	RI (Cald)	RI (Lit)	Composition (%)
o-Thymol	22.018	1173	-	58.21
γ -Terpinene	11.060	1047	1054	23.75
Thymol	21.354	1165	1272	3.42
p-Cymene	9.704	1013	1025	2.87
Endo-Borneol	15.563	1131	1152	0.90
β-Caryophyllene	26.349	1380	1396	0.91
Total components identified				90.06

Table 10. Chemical composition of *Boswellia papyrifera* oil.

Compounds	RT	RI (Cald)	RI (Lit)	Composition (%)
Incensole	24.4437	2151	2158	53.04
Pulespenone	23.9118	1336	1354	46.95
Total components composition identified				99.99

As shown in Table 10, In GCMS analysis, Incensole (53%) and Pulespenone (46.95%) were found in hexane extracted oil of oleo gum resins of *B. papyrifera*. The retention indexes of the identified fragrance compounds are included (Babushok *et al*., 2011; Babushok and Zenkevich 2009; Goodner 2008). According to Bekana, *et al*., (2014) the oil of B. papyrifera is mainly characterized by the presence of octyl acetate (57.1–65.7%) and n-octanol (3.4–8.8%). Because of its noteworthy scent and use as an important fixative in perfumes, soaps, creams, lotions, and detergents, the perfume and cosmetic industry have considerable interest in the production of frankincense (Dominic *et al*., 2018). The methanol extract of *B. papyrifera* resin collected from Humera area revealed components with a retention time of 20.87, 24.83, 24.95, and 26.25 min which were identified as incensyl acetate, *β*-amyrenone, *β*-amyrin, and *α*-amyrin, respectively (Bekana *et al*., 2014).

Perfume formulation and Hedonic Test

In this study, thirty perfumes in different proportions of essential oils and ethanol were prepared. The thirty perfume samples were prepared by mixing eight fragrant oils up to 15 ml and their stability was analyzed at 25^0C and 35^0C.

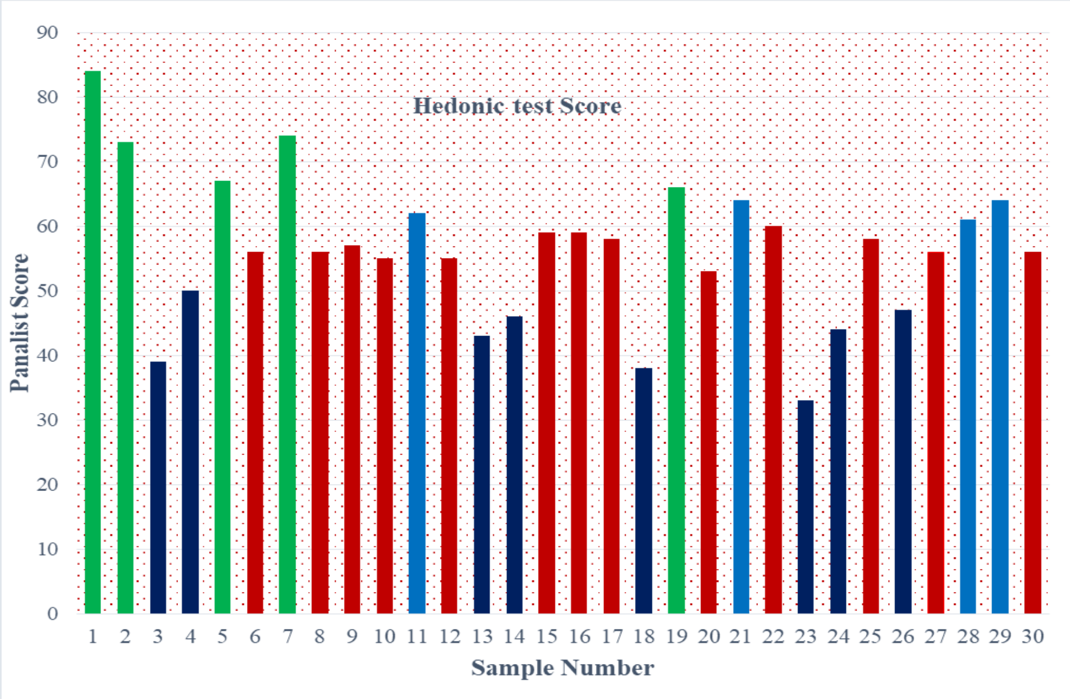

Figure 1. Panelists' evaluation score of prepared perfume samples.

Perfume is valued both for its appearance and its fragrance. Perfumes come in many colors, including clear, gold and brown. These colors are a consequence of the natural ingredients used to create perfume. Since exposure to heat adversely affected each of these characteristics, hot temperatures can decrease a perfume's value. Excess heat can alter the top notes of a perfume. Hot temperatures can cause a perfume's colour to darken or to become cloudier and opaquer. According to Mandavgane *et al*.(2009) perfume samples with ethanol carrier solvent exhibited good perfumery properties. After formulations, the prepared perfume samples were presented to the panelists and participant preferences were assessed using preset criteria. The panelists were grouped in their age, gender and social status and then the feedback was collected by hedonic test criteria.

Based on the assessment statistics the formula with greater preference is formulation numbers 1,2,5,7 and 19. Formula 1 was prepared from *Lavandula angustifolia* as top note; *Cymbopogon martini* as a middle note and *Boswellia papyrifera* as a base note whereas formula 2 was made from *Cymbopogon nardus* as top note; *Rosmarinus officinalis* as a middle note and *Boswellia papyrifera* as a base note. The third formula 5 was composed of *Lavandula angustifolia* and *Juniperus* *procera* as a top note, *Cymbopogon martini* and *Foenculum vulgare* as middle note and *Boswellia papyrifera* as a base note. This data indicated that the aroma of the above listed fragrant oils are pleasant and for this reason, priority is given to formula that contains *Lavandula angustifolia* and *Cymbopogon nardus* as top note; *Cymbopogon martini and Rosmarinus officinalis* as a middle note and *Boswellia papyrifera* as a base note. The lower value of preference was given for formulas 23, 3 and 18 which are composed of *Juniperus procera*, *Cymbopogon nardus* and *Lavandula angustifolia* as a base note; *Thymus schimperi* as a middle note and *Boswellia Papyrifera* as a base note. According to the assessment, the presence of thyme essential oil in this formula gave a negative impact and resulted in lower panellist preferences.

Conclusions

This research indicated the importance of plant essential oils as sources of aromatic compounds for the preparation of local perfumes, and their role to improve the livelihood of the growers. This is an attempt to explore the possibility of perfume manufacturing using plant essential oils. The panelist response for formulated perfume samples containing *Lavandula angustifolia* and *Cymbopogon nardus* as top note; *Cymbopogon martini and Rosmarinus officinalis* as a middle note and *Boswellia papyrifera* as a base note showed high customer satisfaction for use of the formulated perfumes.

Acknowledgment

The authors are indebted to Debre Berhan University for financial and material support.

Conflict of interests

The authors declare that they have no competing interests.

References

Alemu, A., Mathewos, A., Desta, E., Ashenafi, K., Gewado, A., Kagnuro, G. (2017). In-Vitro and In-Vivo Antibacterial Activities of Croton macrostachyus Methanol Extract against *E. coli* and *S. aureus*. *Advances in Animal and Veterinary Science*, 5(3): 107-114.

Alfred, M. (2017). Ethnopharmacological Uses, Phytochemistry, and Pharmacological Properties of Croton macrostachyus Hochst. Ex Delile: A Comprehensive Review. *Evidence-Based Complementary and Alternative Medicine*, 2017: 1-17.

Ayele, D. T., Akele, M. L., & Melese, A. T. (2022). Analysis of total phenolic contents, flavonoids, antioxidant and antibacterial activities of Croton macrostachyus root extracts. *BMC chemistry*, *16*(1), 30, 1-9.

Belay, G., Tariku, Y., Kebede, T., Hymete, A., Mekonnen, Y. (2011). Ethnopharmacological investigations of essential oils isolated from five Ethiopian medicinal plants against eleven pathogenic bacterial strains. *Phytopharmacology*, 1(5): 133-143.

Fokunang, C.N., Ndikum, V., Tabi, O.Y., Jiofack, R.B., Ngameni, B., Guedje, N.M., Tembe-Fokunang, E.A., Tomkins, P., Barkwan, S., Kechia, F., Asongalem, E., Ngoupayou, J., Torimiro, N.J., Gonsu, K.H., Sielinou, V., Ngadjui, B.T., Angwafor, F., Nkongmeneck, A., Abena, O.M., Ngogang, J., Asonganyi, T., Colizzi, V., Lohoue, J., Kamsu K. (2011). Traditional Medicine: Past, Present and Future Research and Development Prospects and Integration in the National Health System of Cameroon. *African Journal of Traditional Complementary and Alternative Medicine*, 8(3): 284–295.

Dubale, A. A., Chandravanshi, B. S., Gebremariam, K. F. (2015). Levels of major and trace metals in the leaves and infusions of Croton Macrostachyus. *Bulletin of the Chemical Society of Ethiopia*, 29(1): 11-26.

Fekam B. F., Zambo A. E., Amvam Z. P. H., Agnaniet, H., Menut, C., Bessière, J. M. (2003). Aromatic plants of tropical central Africa. Part XLII. Volatile components from *Antidesma laciniatum Muell. Arg. var. laciniatum* growing in Cameroon. *Flavour and fragrance journal*, 18(5): 451-453.

Gurib, F. A. (2006). Medicinal plants: traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine*, 27: 1–93.

Harvey, A. L. (2007). Natural products as a screening resource. *Current Opinion in Chemical Biology*, 11:480–484.

Kapingu, M. C., Guillaume, D., Mbwambo, Z. H., Moshi, M. J., Uliso, F. C., Mahunnah, R. L. (2000). Diterpenoids from the roots of *Croton macrostachys*. *Photochemistry*, 54(8): 767-770.

Liu, W. J. (2011). Introduction to traditional herbal medicines and their study. *Traditional Herbal Medicine Research Methods: Identification, Analysis, Bioassay, and Pharmaceutical and Clinical Studies*, 1-26.

Mahesh, B., & Satish, S. (2008). Antimicrobial activity of some important medicinal plant against plant and human pathogens. *World journal of agricultural sciences*, 4(5): 839-843.

Megersa, M., Asfaw, Z., Kelbessa, E., Beyene, A., & Woldeab, B. (2013). An ethnobotanical study of medicinal plants in Wayu Tuka district, east Welega zone of oromia regional state, West Ethiopia. *Journal of ethnobiology and ethnomedicine*, 9(1): 68.

Mekonnen L. B. (2015). In vivo antimalarial activity of the crude root and fruit extracts of Croton macrostachyus (Euphorbiaceae) against Plasmodium berghei in mice. *Journal of traditional and complementary medicine*, *5*(3), 168–173.

Minyamer, T., & Belay, G. (2018). In Vitro Antibacterial Effects of Chloroform, Methanol and Water Extracts of Croton Macrostachyus Stem Bark Against Escherichia Coli and Staphylococcus Aureus Standard and Clinical Strains. *The International Journal of Biotechnology*, 7(1): 1-7.

Pagadala, V. K., Tsegaye, B., Kebede, N., Elias, T., & Gemachu, G. (2015). Significance of traditional medicinal plants used for treatment of rabies at Ambo town. *Medicinal and Aromatic Plants*, 4(4): 1-6.

Rehecho S, Uriarte-Pueyo, I., Calvo J, Vivas, L. A, Calvo M. I. (2011). Ethnopharmacological survey of medicinal plants in Nor-Yauyos, a part of the Landscape Reserve Nor-Yauyos-Cochas, Peru. *Journal of Ethnopharmacology*, 133:75–85.

Reynolds, W. F., McLean, S., Poplawski, J., Enriquez, R. G., Escobar, L. I., & Leon, I. (1986). Total assignment of ^{13}C and ^{1}H spectra of three isomeric triterpenol derivatives by 2D NMR: an investigation of the potential utility of ^{1}H chemical shifts in structural investigations of complex natural products. *Tetrahedron*, 42(13): 3419-3428.

Ríos J. L, Recio M. C. (2005). Medicinal plants and antimicrobial activity *Journal of Ethnopharmacology*, 100:80–84

Salem, M. Z. M., Aly, H., Gohar, Y., El-Sayed, A. W. (2013). Biological activity of extracts from Morus alba L., Albizzia lebbeck (L.) Benth. and Casuarina glauca Sieber against the growth of some pathogenic bacteria. *International Journal of Agricultural and Food Research*, 2(1): 9-22.

Pan, S.-Y., Gerhard, L., Gao, S.-H., Zhou, S.-F., Yu, Z.-L., Chen, H.-Q., Zhang, S.-F., Tang, M.-K., Sun, J.-N., Ko, K.-M. (2014). Historical Perspective of Traditional Indigenous Medical Practices: The Current Renaissance and Conservation of Herbal Resources. *Evidence-Based Complementary and Alternative Medicine*, 1-20.

Tala, M. F., Tan, N. H., Ndontsa, B. L., Tane, P. (2013). Triterpenoids and phenolic compounds from *Croton macrostachyus*. *Biochemical Systematics and Ecology*, (51): 138-141.

Shen, Q. W. (2016). Antidiabetic and antihyperlipidemic activities of Forsythia suspensa (Thunb.) Vahl (fruit) in streptozotocin-induced diabetes mice. *Journal of ethnopharmacology*, *192*, 256-263.