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Biochemical composition, oil profiling and elemental analysis of different cumin (*Cuminum cyminum* L.) genotypes

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Abstract

Cumin (*Cuminum cyminum* L.) is an annual plant of the family *Apiaceae* and the genus *Cuminum* has a single species *Cyminum*, native from the east Mediterranean to east India. In India, Gujarat and Rajasthan are the major producing states. After black pepper, cumin is the second most popular spice in the world. The present research work was carried out to study the nutritional quality parameters, oil profiling and element composition of fifteen cumin genotypes. The results showed that the moisture content was found to vary from 6.22 to 8.15 %. The carbohydrate content was higher in Kushalpura-1 (46.14 %), while the crude protein was highest in Indawar followed by GC-2 and Merta-2. Total protein content was highest in Lampolai (18.24 %) and lowest in GC-2 (11.36 %). In Lamba Jatan, highest content of non-reducing sugars (8.35 %) and total soluble sugars (9.11 %) were observed. Reducing sugars was detected in the range of 0.72 – 1.53 %. Highest amount of total free amino acids and crude fiber were found in Gawardi and Kushalpura-1, respectively. The total oil (20.27 %) and volatile oil (3.99 %) content were highest in GC-4. The petroselinic acid and linoleic acid were observed as primary fatty acids in all tested genotypes. However, Lampolai, Merta-1, GC-2 and GC-4 were good sources of both fatty acids among all the genotypes. The elemental analysis showed that the GC-2 has a high overall amount of macronutrients, while micronutrients was highest in Piplon-5.

Keywords: Cumin, nutritional quality, oil profiling, element analysis.

Introduction

Spices are the most common agricultural commodity used for various purposes. Spices, due to the presence of volatile oil are used for perfume making and as a seasoning in curry powders, soups, sausages, cheeses, pickles, meats and chutneys. Spices are highly cherished natural products due to their antioxidant and antimicrobial properties (Singh *et al*., 2017). Traditionally spices, as part of the diets, have holistic effects on human health. India is a major producer of several spices. Out of over 80 types

of spices grown in the world, about 50 are grown in India. Spices also show activity against neurodegenerative diseases, a group of progressive neurological disorders that damage the function of neurons (Bhagya *et al.*, 2017).

Cumin (*Cuminum cyminum* L.) is an annual plant of the family *Apiaceae* and the genus *Cuminum* has a single species *Cyminum*, native from the east Mediterranean to east India. The word cumin in English is derived from the Latin "*Cuminum*", which itself derived from the Greek word "*Kyminon*". The basic chromosome number of cumin is X = 7 (Rai *et al*., 2012). Cumin seeds have an oblong shape, thicker in the middle, compressed laterally with nine ridges and is yellow-brown in colour. The cumin plant requires a moderately cool and dry climate for its growth, with a temperature between 25-30 °C. India is largest producer of cumin with an area of 4.51 Mha, 0.856 MT production and a production of 0.7 tonnes ha^{-1}. In India, Gujarat and Rajasthan are the major producer states. During 2020-21, area, production and productivity of 0.71 Mha, 1.03 MT tonnes and 1.44 tonnes ha^{-1} respectively in Gujarat, 1.08 Mha, 1.23 MT and 1.14 tonnes ha^{-1}, respectively in Rajasthan (Anon, 2019).

After black pepper, cumin is the second most popular spice in the world. The dried cumin seed contains moisture (8.06 %), carbohydrate (44.24 %), protein (17.8 %), total fat (22.3 %), total soluble sugar (2.25 %), dietary fiber (10.5 %), ash (7.62 %), niacin (4.58 mg/100g), riboflavin (0.33 mg/100g), thiamine (0.62 mg/100g), vitamin A (1270 IU), vitamin C (7.7 mg/100g), vitamin E (3.33 mg/100g), vitamin K (5.4 µg/100g), electrolyte sodium (0.16 g/100g), potassium (1.79 g/100g), calcium (0.93 g/100g), copper (0.86 mg/100g), iron (0.06 mg/100g), magnesium (0.36 mg/100g), manganese (0.03 g/100g), phosphorus (0.49 g/100g), zinc (4.8 mg/100g) and selenium (5.2 µg/100g) (Anon, 2019).

In India, cumin is used as an abortifacient, treating kidney and bladder stones, chronic diarrhoea, leprosy etc. In Unani system of medicine, the fruits of *Cuminum cyminum* is used as an astringent, carminative, emmenagogue, for the treatment of corneal opacities, ulcers, boils, styes and to relieve cough and inflammation. Cumin helps in decreasing hypoglycemia and high blood glucose level by stimulating the secretion of the hormone insulin in diabetic patients. It is said to be a good general tonic and stimulant for the body. Cumin relieves flatulence, bloating, and other related stomach ailments. It can relax muscles and prevent muscle cramps. Cumin oil acts as a disinfectant and helps in treating the common cold and fever caused by viral infections. Cumin oil possesses hypnotic and sedative properties which helps insomnia patients in relieving fretfulness and tension to get better sleep (Khan, 2018). Therefore, the present study was planned to highlight various nutritional and chemical properties of different cumin (*Cuminum cyminum*) genotypes. In this context, research work was undertaken to elucidate various quality parameters, antioxidant compounds and mineral analysis of different cumin genotypes.

Materials and methods

Experimental details

Fifteen genotypes of cumin *viz.,* Kulmipura, Piplon-3, Piplon-5, Lampolai, Arniyala, Gawardi,

Dholerao Khurd, Lamba Jatan, Indawar, Merta-1, Merta-2, Merta-3, Kushalpura-1, GC-2 and GC-4 were grown at Seed Spices Research Station, Anand Agricultural University following Good Agricultural Practices and seed samples were collected. All the (reagents and solvents) used in the experiments were of high purity, analytical, HPLC grades and were obtained from standard manufacturers.

Biochemical and quality parameters

Moisture content, total carbohydrate content and fibre content were determined as per Sadasivam and Manickam (1992). Total soluble sugars was estimated as per Dubois *et al.* (1956). Reducing sugars were determined as suggested by Miller (1959). The non-reducing sugars was calculated by subtracting the reducing sugars values from the total sugars in each sample separately. Crude protein content from seed powder was estimated by Kjeldahl method (AOAC, 1970). Total protein content was determined by Folin-Lowry method (Lowry *et al.* 1951). Total oil from the seeds was extracted by using the Soxhlet method as per Ravi *et al*. (2013). The hydro-distillation method described by Merah *et al*. (2020) was used to estimate volatile oil from cumin seed. Volatile oil was extracted from 100 g cumin seeds in a Clevenger type apparatus for 3-7 hrs, followed by storing at 4°C.

Fatty acid profiling

Standard preparation

The mixture of 37 fatty acid methyl ester was procured and used as a standard solution. From this mixture, the working standards of different concentrations of 10, 25, 50, 100 and 200 mg L^{-1} were prepared in petroleum ether for the linearity of standard curves (Fig. 2A).

Sample preparation

Oil profiling was done as per Sadasivam & Manickam (1992) with some modifications. A quantity of 300 mg oil, collected from seeds of each sample using the Soxhlet method, was taken in the 100 mL of volumetric flask. Precisely, 15 mL of 1 N NaOH was added and the flasks were boiled at 95°C for 5 mins in water bath. The sample was kept to cool down at room temperature. After cooling, 2 mL of boron trifloride (BF_3) was added and boiled again at 95°C for 5 mins. After cooling, 6 mL of 36% NaCl was added for saturation of sample. For the separation, 1 mL of petroleum ether was added and after settling down, upper layer of ether was used for further analysis in GC-FID.

Instrument operating parameters

The samples were incubated under dark conditions for 40 min at 4˚C to allow equilibration and sedimentation of particles. For the detection and separation of various fatty acids from oil, a gas chromatograph (Thermo Trace 1110) coupled with Flame Ionization Detector (FID) detector was used. The column SP-2560 (100m X 0.25 mm i.d. 0.2 µm) was used for the separation of the fatty acids. The injector temperature was set at 230°C. The oven temperature was as follow: 120°C (hold for 2 mins) @ 4°C min^{-1} to 210°C (hold for 3 mins) @ 7°C min^{-1} to 230°C (10 mins). The nitrogen gas was used as carrier gas at a constant flow of 1.5 mL min^{-1}. The detector temperature was set at 250°C. The total run time was 40 mins. The peaks of each compound were identified by comparing retention times of standards and the

peak area was calculated automatically by integrating the peak with the baseline. The concentration of each compound was calculated according to the equation based on the ratio of the peak areas of the respective standard and sample.

Element analysis by ICP-MS

Standard preparation

A mixture of stock standard (10 mg L^{-1}) was prepared from 100 mg L^{-1} of each element (P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo, B, Cd, Pb, Co, Cr and Ni) using 5 % HNO_3. The working standards were prepared from the stock solution in the range of 0.1, 0.25, 0.5, 1, 2.5 and 5 mg L^{-1} by serial dilution. Nitrogen content was analyzed by micro Kjeldahl method.

Sample preparation

Mineral nutrients were determined using the method given by Tokalioglu *et al.* (2018). A 0.5 g of each sample was accurately weighed in Polytetrafluoroethylene (PTFE) digestion vessel. In this vessel, 4 mL of concentrated nitric acid, 2 mL of hydrogen peroxide and 4 mL of milli-Q water were added. Decomposition of the samples was carried out in a microwave digestion system. A five step programme (Table 1) was applied to the sample. After cooling, the extract was transferred into 50 mL capacity centrifuge tube and made up to 50 mL with milli-Q water. The samples were analyzed in Inductive Coupled Plasma- Mass Spectrometry (ICP-MS)

Table 1. Microwave digestion programme for the decomposition

Step	Power	Temp. (^{0}C)	Time (min)	Mode
1	1500	50	2	Ramp
2	1500	120	5	Hold
3	1800	190	2	Ramp
4	1800	210	15	Hold
Cooling with water	-	-	30	-

Instrument detail

An Agilent 7900 model ICP-MS system was used for multi-element analysis. The matrix for plasma mode was set to low (0.1 %). The carrier gas argon was passed at a rate of 1.05 L min^{-1} throughout, while the helium flow rate was adjusted to 4.3 mL min^{-1}. The data was analyzed using mass hunter software.

Statistical analysis

The data collected for different observations were subjected to statistical analysis of variance technique as described by Panse & Sukhatme (1967). Treatment means of all characters studied were further compared using critical differences at 5 % level of significance employing the "F" test. The CV % was also worked out for all the treatments.

Results and discussion

Quality parameters

Various quality parameters were carried out to classify a better cumin genotypes among all the tested genotypes. The results of all the tested quality parameters are presented in Table 2. Moisture content is important for keeping

quality and shelf life of seeds as it decreases the probability of heating damage, ageing and insect damage and many biochemical changes associated with these processes. It was considerably diverse in all evaluated genotypes. The genotype Merta-3 had the highest moisture content (8.15%). However, Lampolai, Kulmipura, Lamba Jatan, Kushalpura-1, and Piplon-3 genotypes were found to have favourable low moisture content. Mandal and Mandal (2016) and Dar *et al.* (2019) also recorded cumin seed moisture content as 6% and 8.06% respectively.

The carbohydrate content of various cumin genotypes ranged from 30.53 to 46.14%. Kushalpura-1 had a higher carbohydrate content (46.14%), whereas Piplon-3 had a lower carbohydrate content (30.53%). Similar outcomes were perceived by Mandal and Mandal (2016) and Dar *et al.* (2019). The maximum content of total soluble sugar was found in Lamba Jatan (9.11%) followed by Merta-1 (8.85%), Dholerao Khurd (8.75%) and GC-2 (8.73), while, lower in Indawar (6.90%). The reducing sugars was found in the range of 0.72 - 1.53% in all tested genotypes. The genotypes Merta-1, Kushalpura-1, Kulmipura, Arniyala, Piplon-5 and Merta-2 were found to have higher reducing sugar content *viz.,* 1.53 %, 1.30 %, 1.22 %, 1.12 %, 1.04 % and 1.04 % respectively above the rest of the genotypes (Table 2). The results obtained are akin to the outcomes of Bouhenni *et al*. (2019). The significantly high non-reducing sugar content was recorded in genotype Lamba Jatan (8.35 %), which was at par with Dholerao Khurd (8.03 %) (Table 2). The results indicate a strong correlation between total soluble sugars and non-reducing sugars at 1% level (Fig. 1).

The range of crude protein in cumin genotypes was 26.98–35.94%. Indawar had a maximum content of crude protein, 35.94 %, while Kulmipura had the lowest 26.98%. (Table 2). Badr & Georgiev (1990) reported a similar finding of crude protein (23%) in cumin seeds. Total protein content in cumin genotypes ranged from 11.36 to 18.24 %. It was found to be higher in genotypes Kulmipura, Dholerao Khurd, and Lampolai than in the others. Various scientists have also reported that the protein content of cumin ranges between 17.5 and 19.0 % (Mandal & Mandal, 2016; Toghrol & Daneshpejouh, 1974; Dar *et al*., (2019; Milan *et al.,* 2008). Total protein content was positively and significantly correlated with nitrogen content of cumin seeds at 1 % level. The free amino acid content was positively correlated with crude protein at 5 % level (Fig. 1).

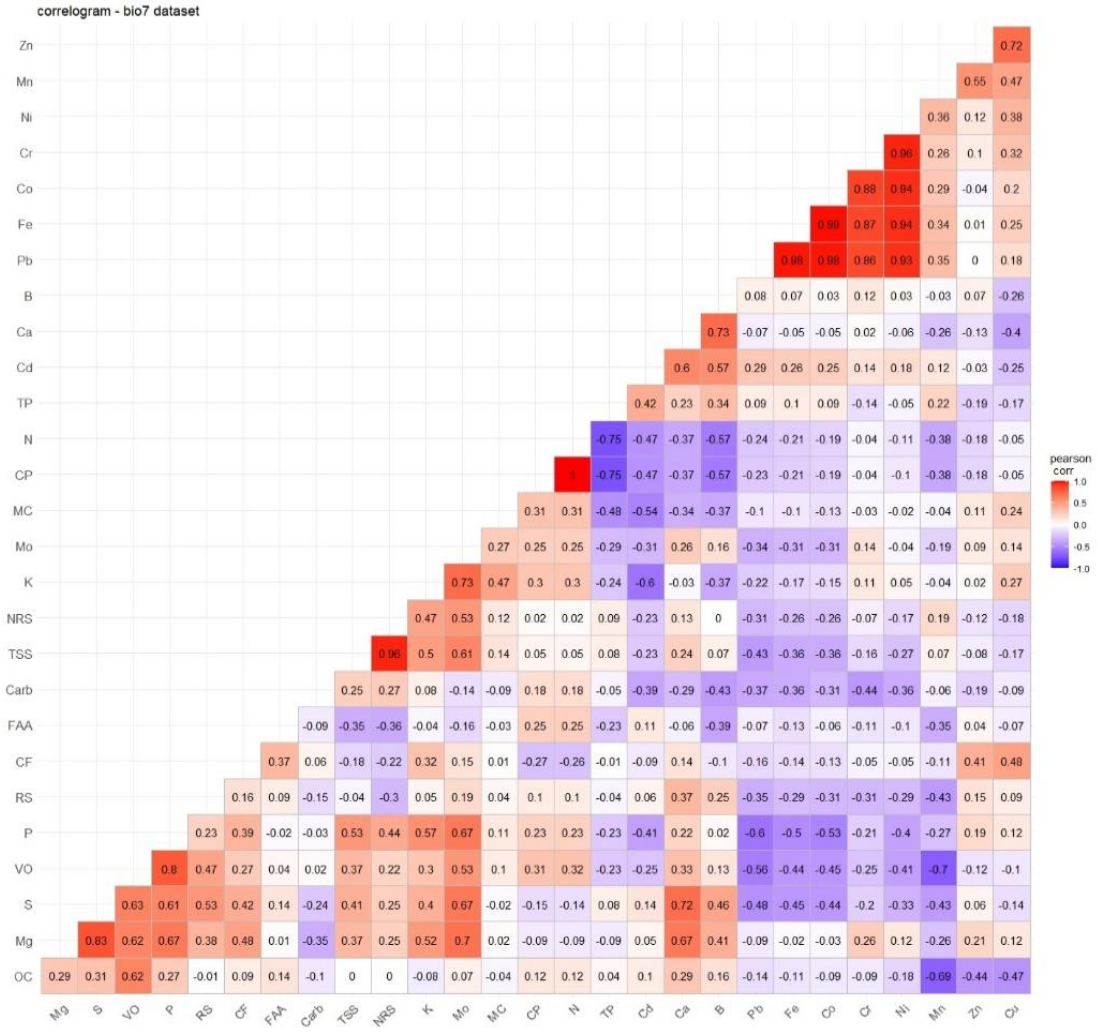

Fig. 1. Correlation coefficient of different variables in cumin genotype.

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Table 2. Quality parameters analysis of different cumin genotypes

Genotype	Moisture (%)	Carbohyd rate (%)	Crude protein (%)	Total protein (%)	Total soluble sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Crude fiber (%)	Total free amino acid (%)	Total oil content (%)	Volatile oil (%)
Kulmipura	6.41	31.01	26.98	17.82	7.38	1.22	6.16	12.91	2.09	18.47	2.94
Piplon-3	6.58	30.53	30.83	15.42	6.97	0.97	6.00	12.38	1.78	19.20	3.25
Piplon-5	8.07	33.43	31.52	13.16	7.20	1.04	6.16	14.81	2.31	12.47	1.75
Lampolai	6.22	41.97	29.24	18.24	6.94	0.77	6.16	16.16	2.05	14.47	2.09
Arniyala	7.22	45.44	31.94	13.06	7.49	1.12	6.36	11.57	1.83	13.67	2.58
Gawardi	7.13	40.37	32.43	15.67	7.03	0.80	6.23	12.15	2.35	16.60	1.66
Dholerao Khurd	7.34	43.19	27.05	17.82	8.75	0.72	8.03	11.83	1.15	15.80	2.08
Lamba Jatan	6.44	45.13	32.55	16.62	9.11	0.76	8.35	8.85	2.06	16.40	2.45
Indawar	7.52	36.76	35.94	13.92	6.90	0.91	5.98	10.35	2.08	18.47	2.35
Merta-1	7.44	37.98	34.04	16.77	8.85	1.53	7.32	10.94	1.82	16.27	3.97
Merta-2	7.73	45.30	35.76	13.20	7.21	1.04	6.16	12.32	1.96	19.93	3.66
Merta-3	8.15	37.26	28.12	17.09	8.18	0.90	7.27	17.05	2.11	19.53	3.42
Kushalpura-1	6.58	46.14	30.92	15.47	7.46	1.30	6.16	20.97	2.34	18.60	3.73
GC-2	7.59	38.03	35.79	11.36	8.73	0.95	7.78	15.67	1.92	16.13	3.75
GC-4	7.22	40.16	34.07	13.53	8.51	0.77	7.73	13.51	2.28	20.27	3.99
SEM ±	0.08	0.58	0.53	0.26	0.13	0.02	0.13	0.55	0.05	0.31	0.04
CD at (5 %)	0.24	1.68	1.54	0.74	0.38	0.06	0.37	1.58	0.15	0.89	0.12
CV %	2.02	2.55	2.90	2.90	2.95	3.86	3.29	7.06	4.56	3.12	2.49

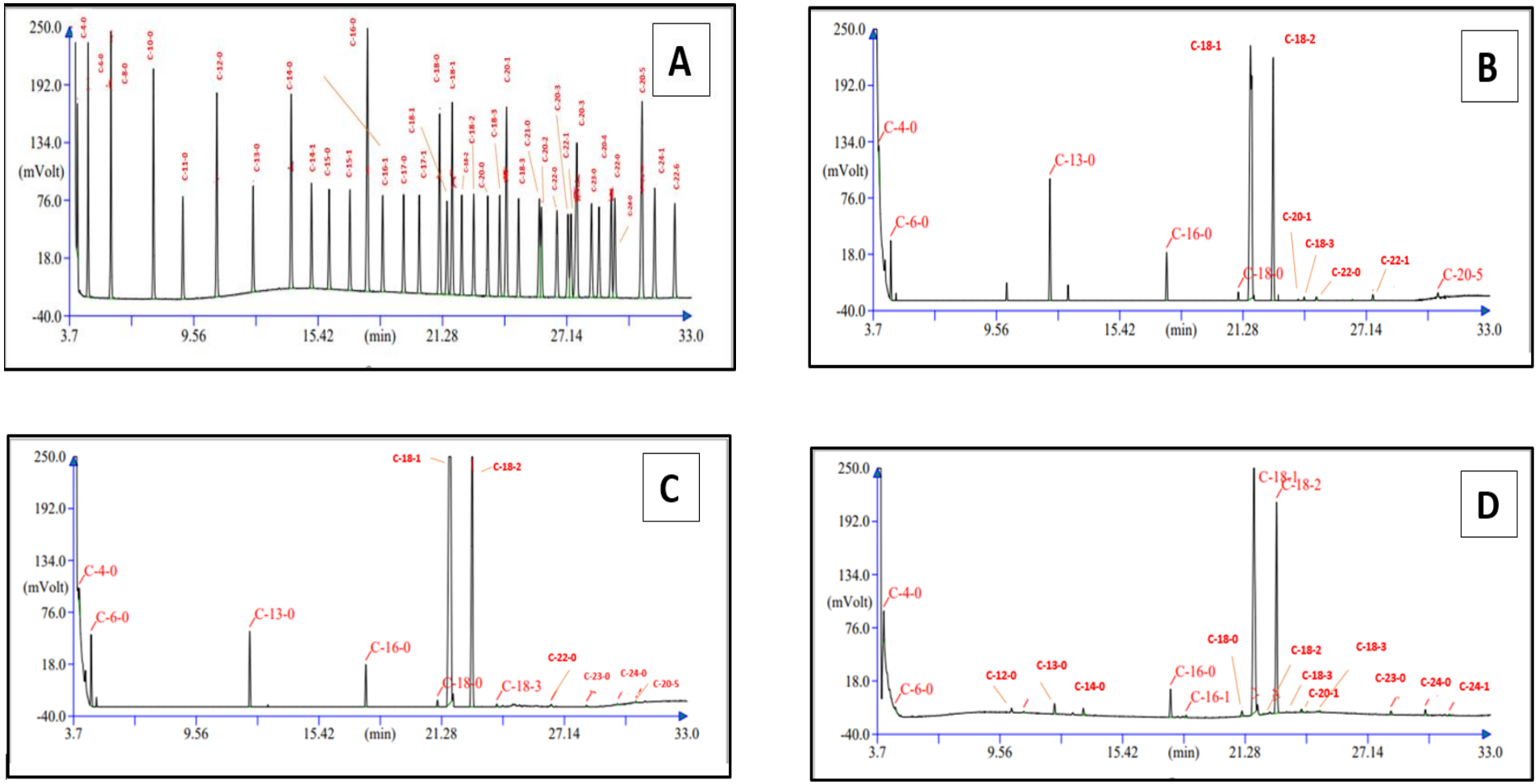

Fig. 2. Chromatogram of oil profiling [A] Standard of 37 mixture of fatty acids [B] Merta-1 [C] GC-2 [D] GC-4

Cumin genotypes had fiber content ranging from 8.85 to 20.97 %. Fiber content was found to be higher in the genotype Kushalpura-1 (20.97%) and lower in Lamba Jatan (8.85%). Merta-3 (17.05%), Lampolai (16.16%), GC-2 (15.67%), and Piplon-5 (14.81%) had significantly higher content than the rest of the genotypes and was at par with Kushalpura-1 (Table 2). Similar findings regarding the crude fiber content (10.5%) of cumin seeds were reported by Dar *et al*. (2019).

Total free amino acid content was higher in genotype Gawardi (2.35 %) and lower in Dholerao Khurd (1.15 %). The free amino acid content in Kushalpura-1, Piplon-5 and GC-4 was at par with Gawardi (Table 2). Toghrol & Daneshpejouh (1974) also reported free amino acid content of 2.32 % in cumin seeds.

Total oil content was found in the range of 12.47 - 20.27 %. A significantly higher amount of oil content was found in GC-4 (20.27 %), which was at par with Merta-2 (19.93 %) and Merta-3 (19.53 %). The lower amount of oil content was reported in genotype Piplon-5 (12.47 %). The perceived result was akin to the findings by Daga *et al.* (2021) and Shahnaz *et al.* (2004). The volatile oil content was found higher in genotype GC-4 (3.99 %), Merta-1 (3.97 %), GC-2 (3.75 %), Khushalpura-1 (3.73 %), Merta-2 (3.66 %), Merta-3 (3.42 %) and Piplon-3 (3.25 %) than the rest of genotypes. Significantly lower volatile oil content was found in Gawardi (1.66 %) (Table 2). Various researchers also reported cumin volatile oil content in the range of 1.6 – 6.0 % {Mandal & Mandal, (2016); Bouhenni *et al*. (2019); Badr & Georgiev (1990); Merah *et al*. (2020); Ravi *et al*. (2013)}. The total oil content was positively correlated with volatile oil content at 5 % level (Fig. 1).

The observed results were specific to this study and comparisons could be indicative. Nevertheless, it is important to mention that the chemical composition of cumin seeds varies considerably depending on the variety, the cultivation practices, the stage of development and the climatic conditions.

Oil profiling

Fatty acid profiling (also known as the analysis of fatty acid methyl esters, or FAME) determines the quality of oil seeds and processed oil by identifying and quantifying the fatty acids present in a sample. Butyric acid was found to vary in the range of 0.35 – 34.06 % in cumin seed oil. The higher content of butyric acid was detected in Piplon-3 and it was lowest in Arniyala. Caproic acid was higher in Kulmipura (16.30 %) and lowest in GC-4 (0.22 %). The genotypes Dholerao Khurd (14.59 %) and Arniyala (11.37 %) had higher caproic acid than the rest of the genotypes. Tridecylic acid varied from 1.35 – 41.59 % in cumin seed oil. The higher amount of tridecylic acid was detected in genotypes Kushalpura-1 (41.59 %), Kulmipura (41.13 %), Arniyala (29.42 %), Piplon-3 (22.45 %), Piplon-5 (19.82 %) and Gawardi (17.19 %) than the rest of genotypes, while it was lowest in GC-4. Palmitic acid was found in the range of 0.14 – 4.27 % in various genotypes. Palmitic acid was found higher in genotypes Merta-2 (4.27 %), GC-4 (3.79 %), Lamba Jatan (3.67 %) and Merta-3 (3.26 %) than the rest of genotypes. Stearic acid was higher in Merta-3 (0.97 %) and lower in Merta-1 (0.09 %) and Arniyala (0.09 %) compared to the rest (Table 3). Chromatograms

of oil profiling of [B] Merta-1 [C] GC-2 [D] GC-4 are shown in Fig 2.

Table 3. Oil profile of different cumin genotypes.

Genotype	Butyric acid (C-4-0) (%)	Caproic acid (C-6-0) (%)	Tridecylic acid (C-13-0) (%)	Palmitic acid (C-16-0) (%)	Stearic acid (C-18-0) (%)	Petroselinic acid (C-18-1) (%)	Linoleic acid (C-18-2) (%)	Linolenic acid (C-18-2) (%)
Kulmipura	0.72	16.30	41.13	0.36	ND	25.96	14.21	ND
Piplon-3	34.06	9.00	22.45	0.14	ND	22.05	11.30	ND
Piplon-5	1.83	4.38	19.82	0.99	ND	47.82	25.06	0.10
Lampolai	0.42	1.65	4.97	2.84	0.29	60.99	29.67	0.02
Arniyala	0.35	11.37	29.42	1.49	0.09	30.75	18.03	0.40
Gawardi	18.06	2.89	17.19	1.54	0.53	37.55	21.52	0.19
Dholerao khurd	2.77	14.59	7.01	2.50	0.83	26.38	17.26	0.10
Lamba Jatan	2.69	3.41	8.49	3.67	0.82	48.72	24.93	0.31
Indawar	18.36	3.67	13.61	2.27	0.53	37.30	20.17	0.26
Merta-1	2.70	4.12	7.72	2.26	0.09	55.03	27.43	ND
Merta-2	1.00	4.16	10.91	4.27	0.43	51.82	26.25	ND
Merta-3	0.92	6.75	10.48	3.26	0.97	47.27	23.64	0.36
Kushalpura-1	11.47	8.91	41.59	ND	ND	24.87	11.39	ND
GC-2	0.84	4.29	5.04	2.81	0.41	59.01	27.13	0.15
GC-4	2.32	0.22	1.35	3.79	0.78	56.81	31.10	0.11
SEM ±	0.15	0.08	0.30	0.03	0.02	0.76	0.40	0.00
CD at (5 %)	0.43	0.24	0.87	0.08	0.05	2.19	1.16	0.01
CV %	3.88	2.27	3.24	2.34	7.05	3.12	3.16	3.81

* ND: Not detected

Petroselinic acid was detected in the range of 22.05 – 60.99 % in the fifteen genotypes. It was highest among all fatty acid studied. The genotypes Lampolai (60.99 %), GC-2 (59.01 %), GC-4 (56.81 %), Merta-2 (51.82 %), Lamba Jatan (48.72 %) and Piplon-5 (47.82 %) had high quality petroselinic acid among different genotypes. The linoleic acid was found in the range of 11.30 – 31.10 %. The linoleic acid was detected higher in GC-4 (31.10 %) and lower in Piplon-3 (11.30 %). The genotypes Lampolai (29.67 %), Merta-1 (27.43 %), GC-2 (27.13 %), Merta-2 (26.25 %), Piplon-5 (25.06 %), Lamba Jatan (24.93 %) and Merta-3 (23.64 %) had higher content than the rest of other genotypes. Linolenic acid was found in the range of 0.02 – 0.40 %. The higher linolenic acid was found in Arniyala (0.40 %), followed by Merta-3 (0.36 %) and Lamba Jatan (0.31 %) (Table 3). The source of variability may be genetic (cultivar, variety) or due to seed variables, quality, oil processing and accuracy of the quantification technique (Amin *et al.,* 2010). Similar results were reported by various researchers {Karik *et al.* (2022); Nickavar *et al*. (2003); Ali *et al.* (2012); Amin *et al.* (2010); Bettaieb *et al*. (2011) and Shahnaz *et al.* (2004)}.

Elemental analysis

Macronutrients, are the natural elements the body needs in large amount to remain healthy and are more important than any other minerals. Macronutrients (carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium and Sulphur); Micronutrients (iron, manganese, zinc, copper, molybdenum and boron) and toxic elements (cadmium, lead, chromium, cobalt and nickel) were observed in the present study. Micronutrients are required in very small amounts. Toxic elements are a subject of great concern and their levels, especially in aromatic spices, need careful monitoring. The limit on trace elements imposed by the European Pharmacopoeia (European Pharmacopoeia commission, 2011) for herbal drugs are set only for Pb (5 mg kg^{-1}) and Cd (1 mg kg^{-1}) (US-EPA, 2009). However, WHO recommendations for the maximum permissible levels of Cd and Pb in medicinal plants are 0.3 mg kg^{-1} and 10 mg kg^{-1}, respectively (WHO, 2000). The permissible limit of Cr recommended by WHO is 30 mg kg^{-1} in spices (WHO, 1998). According to FAO/WHO, (2010) permissible limits of Cd, Ni and Pb in spices were 0.2, 1.63, 5.0 mg kg^{-1}, respectively.

The results of elements analysis are shown in the Table 4. The nitrogen content in cumin genotypes varied significantly with a range of 4.32 - 5.75 %. The highest nitrogen content was observed in the genotype Indawar (5.75 %) and was remarkably lower in Kulmipura (4.32 %). Significantly higher phosphorus content was observed in the genotypes GC-4 (0.45 %) and GC-2 (0.45 %) followed by Merta-1 (0.41 %), Kushalpura-1 (0.39 %), Merta-3 (0.37 %), Lampolai (0.35 %) and Piplon-3 (0.34 %). Phosphorus content was found lower in Gawardi (0.23 %). Potassium content in the cumin genotypes varied in the range of 2.34 - 3.13 %. Significantly higher potassium content was observed in the GC-2 (3.13 %) and lower in Kulmipura (2.34 %). Significantly higher calcium content was observed in the genotypes Kulmipura (1.12 %) which was at par with Kushalpura-1 (1.08 %). Higher magnesium content was observed in GC-2 (0.31 %), which was at par with Kushalpura-1 (0.30 %), whereas lowest was found in Merta-2 (0.22 %) and Lampolai (0.22 %). The sulphur content in the cumin genotypes varied in the range of 0.41-0.57 %. According to Bouhenni *et al*. (2019) the elements content in cumin seed were: P (0.38 %), K (1.46 %), Ca (0.81 %), Mg (0.26 %) and S (0.34 %). Similar results were reported by Moawad *et al*. (2015); Mandal & Mandal (2016); Kabir *et al*. (2019) and Parthasarathy *et al*. (2008).

The genotypes significantly varied from each other with respect to iron content. Iron content was detected in the range of 182.4 – 1897.5 ppm in all tested cumin genotypes. The higher iron content was found in genotype Piplon-3 (1897.5 ppm) and Gawardi (1665.0 ppm) than in the rest of the genotypes. The manganese content was markedly higher in genotype Piplon-5 (62.88 ppm) and lower in genotype Merta-2 (29.05 ppm). The zinc content was detected between 61.14 - 92.63 ppm (Table 4). The genotype Lampolai (11.62 ppm) and GC-2 (11.65 ppm) were found at par with Piplon-5 (12.36 ppm). Molybdenum was found in a very lower amount in cumin seeds with the range of 0.19 – 0.65 ppm. The highest amount of Mo was detected in

GC-2 and the lowest was in Lampolai. Boron content was found higher in Kulmipura (88.32 ppm) and lowest in Gawardi (24.23 ppm) (Table 4). A similar result was observed by Cicero *et al.* (2022), Parthasarathy *et al*. (2008), Bouhenni *et al*. (2019) and Kabir *et al*. (2019) who reported Fe (133-426 mg kg^{-1}), Mn (15.87- 60 mg kg^{-1}), Zn (60-100 mg kg^{-1}), Cu (10-15 mg kg^{-1}), Mo (0.30 mg kg^{-1}) and B (22.0 mg kg^{-1}) in cumin seeds.

The amount of all toxic elements studied in the present work was found below the permissible limits set by various organizations. Cadmium was detected within range of 0.06 – 0.13 ppm in cumin seed. The lower amount of cadmium was observed in genotypes GC-4 (0.06 ppm), which was at par with GC-2 (0.07 ppm), Merta-1 (0.07 ppm) and Merta-2(0.07 ppm). The genotype Merta-1(0.22 ppm), Kushalpura-1 (0.27 ppm), Merta-2 (0.28 ppm), Merta-3 (0.30 ppm) and GC-2 (0.30 ppm) had lower amount of lead. Cobalt content was found higher in genotype Gawardi (0.64 ppm) and Piplon-3 (0.62 ppm). The lower content of cobalt was found in Merta-1 (0.09 ppm), which was at par with Merta-2 (0.10 ppm) and Merta-3 (0.10 ppm) (Table 4). The lower amount of Cr was found in genotypes Kushalpura-1 (0.55 ppm) which was at par with Merta-2 (0.56 ppm), Indawar (0.57 ppm), Merta-3 (0.60 ppm), Arniyala (0.61 ppm), Merta-1 (0.62 ppm) and Lamba Jatan (0.63 ppm). Nickel content detected was in the range of 0.86 - 3.03 ppm. The lower amount of nickel was found in genotypes Arniyala (0.86 ppm) which was at par with Merta-3 (0.87 ppm), Merta-1 (0.89 ppm), GC-4 (0.93 ppm) and Lamba Jatan (0.94 ppm). Tokalioglu *et al*. (2018) and Cicero *et al.* (2022) recorded the concentration of various elements as follows Cd (0.05 ± 0.01 – 0.09 ± 0.01 µg g^{-1}), Pb (0.22 ± 0.02 – 0.59 ± 0.02 µg g^{-1}), Co (0.26 ± 0.01 – 0.35 ± 0.02 µg g^{-1}), Cr (1.14 ± 0.0 – 1.50 ± 0.17 µg g^{-1}) and Ni (2.04 ± 0.10 - 2.81 ± 0.37 µg g^{-1}) in various cumin samples.

P content was positively correlated with K and S at 5 % level and P content exhibited significant positive correlation with Mg and Mo at 1 % level. It had positive correlation with Ca, Zn, Cu and B. K content was correlated with Mg and Mo at 5 and 1 %, respectively. Ca was positively correlated with Mg, S and B at 1 % level. Mg was positively correlated with S and Mo at 1 % level and it had positive correlation with Zn, Cu, B at 55 level and Zn content was positively correlated with Cu at 1 % level. B had positive correlation with Pb, Co, Cr and Ni. Pb content was correlated with Co, Cr and Ni at 1 % level (Fig .1).

Table 4. Element analysis of different cumin genotypes

Genotypes	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Mo (ppm)	B (ppm)	Cd (ppm)	Pb (ppm)	Co (ppm)	Cr (ppm)	Ni (ppm)
Kulmipura	4.32	0.33	2.34	1.12	0.28	0.57	202.9	34.92	75.19	9.57	0.33	88.32	0.13	0.37	0.11	1.18	1.05
Piplon-3	4.93	0.34	2.43	1.02	0.28	0.44	1897.5	40.09	68.32	10.85	0.22	60.40	0.12	0.86	0.62	4.68	3.07
Piplon-5	5.04	0.32	2.65	0.71	0.25	0.43	953.5	62.88	92.63	12.36	0.22	26.80	0.09	0.59	0.32	2.39	2.17
Lampolai	4.68	0.35	2.59	0.62	0.22	0.41	398.3	52.94	74.50	11.62	0.19	26.01	0.08	0.39	0.17	0.98	1.19
Arniyala	5.11	0.31	2.50	0.89	0.23	0.44	236.9	34.98	66.31	9.92	0.23	47.73	0.08	0.35	0.12	0.60	0.86
Gawardi	5.19	0.23	2.72	0.75	0.24	0.42	1665.0	36.53	61.14	10.24	0.24	24.23	0.09	0.90	0.64	4.34	3.27
Dholerao Khurd	4.33	0.33	2.77	0.87	0.26	0.44	980.7	62.31	74.92	10.76	0.31	55.87	0.08	0.58	0.34	2.47	2.13
Lamba Jatan	5.21	0.32	2.49	0.92	0.23	0.45	212.7	49.59	65.37	9.41	0.25	35.87	0.12	0.30	0.12	0.63	0.94
Indawar	5.75	0.32	2.69	0.83	0.23	0.44	194.9	36.45	62.13	9.26	0.23	28.05	0.09	0.36	0.11	0.57	0.97
Merta-1	5.45	0.41	2.93	0.89	0.28	0.53	182.4	32.15	67.07	10.60	0.41	37.71	0.07	0.22	0.09	0.62	0.89
Merta-2	5.72	0.33	2.45	0.58	0.22	0.41	210.3	29.05	72.14	11.02	0.24	26.94	0.07	0.28	0.10	0.56	0.97
Merta-3	4.50	0.37	2.82	0.93	0.27	0.53	198.6	32.14	63.14	10.31	0.33	37.54	0.09	0.30	0.10	0.60	0.87
Kushalpura-1	4.95	0.39	2.76	1.08	0.30	0.55	202.8	30.81	76.00	10.82	0.27	37.69	0.10	0.27	0.13	0.55	1.07
GC-2	5.73	0.45	3.13	0.89	0.31	0.55	198.7	39.51	76.60	11.65	0.65	39.70	0.07	0.30	0.11	3.26	1.94
GC-4	5.45	0.45	2.76	0.84	0.28	0.49	242.3	30.07	69.55	9.42	0.33	33.71	0.06	0.32	0.14	1.44	0.93
SEM ±	0.09	0.01	0.06	0.02	0.01	0.01	6.72	0.70	0.97	0.14	0.01	1.08	0.00	0.01	0.01	0.03	0.03
CD at 5%	0.25	0.02	0.17	0.05	0.01	0.04	19.41	2.02	2.79	0.42	0.01	3.12	0.01	0.03	0.01	0.10	0.09
CV %	2.91	2.77	3.76	3.11	3.31	4.52	2.19	3.01	2.36	2.38	2.66	4.62	6.20	4.58	3.79	3.47	3.59

Conclusion

From the above result, we can conclude that cumin seeds showed a diverse amount of carbohydrates, total oil including volatile (essential oils) and crude fiber in different genotypes. Moreover, these genotypes exhibited high levels of fatty acids particularly petroselinic acid and linoleic acid, which support the nutritive value of cumin as a spice and medicinal plant. The lower amount of toxic elements were detected in all genotypes compared to the maximum permissible level in spices fixed by FAO/WHO.

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