Turkish Journal of Agriculture - Food Science and Technology, 3(7): 515-521, 2015

Turkish Journal of Agriculture - Food Science and Technology

www.agrifoodscience.com,
Turkish Science and Technology

Characterization of Sorghum and Millet with Special Reference to Fatty Acid and Volatile Profile.

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A R T I C L E I N F O

Article history:
Received 26 November 2014
Accepted 07 January 2015
Available online, ISSN: 2148-127X

Keywords:
Cereals
Characterization
Fatty acids
Millet
Sorghum
Volatile profile

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A B S T R A C T

Sorghum and millet are important food staples in semi-arid tropics of Asia and Africa. Sorghum and millet are cereal grains that have prospective to be used as substitute to wheat flour for celiac patients. These are considered as the good source of many important and essential fatty acids. The volatile profiling of these two important crops is comparable to other cereals as well. The present study was an effort to explore biochemical composition of commercially available sorghum and millet varieties with special reference to their fatty acid and volatile profiling. Chemical composition of sorghum and millet was determined according to respective methods. Fatty acid methyl esters were prepared and then subjected to GC-FID for fatty acids analysis. The results indicated that both sorghum and millet oils are rich in essential fatty acids comprising mono and polyunsaturated fatty acids. Main fatty acids that are identified in current study includes palmitic acid, oleic acid, palmitoleic acid, behenic acid, linoleic acid, linoleic acid, stearic acid, myristic acid, etc. On the other hand volatile compounds from sorghum and millet were determined by preparing their respective volatile samples by using calvenger apparatus with suitable volatile extracting solvent. Volatile samples were then subjected to GC-MS analysis and respected results were compared with NIST library. About 30 different volatiles were identified in millet varieties while 35 different compounds were discovered in sorghum varieties belonging to aldehydes, ketones, benzene derivatives, esters, alcohols, sulphur compounds.

Introduction

Food is one of the basic necessities of mankind and is obtained from different sources such as cereals, meat, vegetables, fruits, milk and milk products. Cereals represent major staple foods as they supply large quantity of energy, carbohydrates, protein, micronutrients and fiber to the human diet in developing countries (Sikwese and Duodo, 2007). Sorghum and millet are primary sources of nutrients e.g. protein, mineral, vitamins and energy (Belton and Taylor, 2004). Sorghum is ranked as the 5th most important and valuable crop worldwide after wheat, corn rice and barley is a tropical plant belonging to the Poaceae family (Awika and Rooney, 2004). While Pearl millet (*Pennisatum glaucam*) is cultivated on about 12 million hectares and 15 million hectares in Asia and Africa respectively, consumed as the staple food by a large number of population in India and Africa (Maha et al., 2003). According to the latest researches, an increased interest in usage of finger millet is observed. Potential health benefits includes hypoglycemic features, antioxidant, and antimicrobial activities which are due to its polyphenols (Lakshmi et al., 2002; Chethan and Malleshi, 2007).

Oil extracted from the various cereal grains has peculiar fatty acids with characteristic properties which are important from industrial point of view. The main fatty acids contributing in the human physiology by various ways are saturated, mono and polyunsaturated fatty acids abbreviated as SFA, MUFA and PUFA respectively (Iso et al., 2002; Patil and Gisler, 2006). Most concerned fatty acids are linoleic acid and linolenic acid since both are vital for humans and previous researches have shown that linoleic was the prime fatty acid in sorghum and millet varieties, followed by palmitic acid and oleic acid. The key fatty acid constituents in the oil of sorghum seeds were palmitic (C-16:0), oleic (C-18:1) and linoleic (C-18:2) acids. Moreover unsaturated fatty acid comprises of linolenic acid (C-18:3) and palmitoleic acid (C-16:1) existing in several varieties (Mehmood et al., 2008). According to the research results concentrations of stearic acid, palmitic acid and arachidic acid is (1.2 to 1.4%), (12.1-13.4%) and (0.1-0.2%) respectively. Palmitic and arachidic acid were the highest amound fatty acids in some varieties. While Afify et al. (2012) have found that sorghum contains stearic acid

(1.1-2.6%) and palmitic acid (12.0-20.2%). Whereas Pontieri (2011) have declared that palmitic acid (11.9-14.2%) and arachidic acid (0.1-0.3%) were present in the seed oil of various sorghum varieties.

Mehmood et al. (2008) have found that sorghum varieties contain linoleic acid and oleic acid as major unsaturated fatty acids when analyzed. According to Rooney and Waniska (2000), fatty acids composition of seed oil have declared that the Sorghum bicolor seed oils serve as a potential dietary source of MUFA and PUFA.

The main volatile compounds of cereals include aldehydes, ketones, hydrocarbons, benzene derivatives, alcohols, esters, acids, heterocycles and sulphur. Very little information is available regarding volatile compounds of millet and sorghum. About 50 different types of volatile compounds in millet (Jingke et al., 2012) and among them aldehyde and benzene derivatives were the main compounds in millet. The largest volatile compounds group is aldehyde group in all the identified components. Benzene components were the second most important volatile components. Alcohols, heterocycles, ketones and sulphur compounds were present in minor amounts in aroma compounds of millet (Iso et al., 2002; Jingke et al., 2012).

Materials and Methods

Procurement of raw material

Seven commercially available varieties of sorghum i.e. Chengari, F-114, JS-263, JS-2002, MR-Sorghum, PC-1 and Sandal Bar and two varieties of millet i.e. MB-87 and Sargodha Bajra 2011 were purchased from Ayub Agricultural Research Institute, Faisalabad. Chemicals were purchased from Sigma Aldrich, Labscan etc.

Chemical analysis

The flour of sorghum and millet varieties were evaluated for proximate composition i.e. moisture, ash, crude fat, crude fiber and protein according to the AACC 2000 method.

Fatty acid analysis

Oil from the sorghum and millet was extracted by Soxhlet apparatus using petroleum ether as extraction solvent. The extracted oil was converted into fatty acids methyl esters by using the method adopted by Ryan et al. (2007). By using Pasteur pipettes transferred 100mg±5mg of oil sample to the pyrex test tube with a tight sealing cap. In order to dissolve lipids, added 5ml of hexane and afterwards briefly vortexed. Followed by the addition of 250µl sodium methoxide reagent in the capped test tube and vortex for one minute, pausing every 10 seconds to allowed the vortex to collapse. Added 5ml of saturated NaCl from Rci Labscan to the test tube, capped the test tube and Shake vigorously for 15sec. Let stand for 10 minutes. After that removed the hexane layer and transferred to a vial containing a small volume of Sodium sulphate from Sigma aldrich. FAME should remain in contact with hexane layer having sodium sulphate at least 15 minutes before GC analysis. Transferred the hexane layer to a vial for subsequent GC analysis. GC (Agilent 6890) is used for Fatty acid methyl esters analysis equipped with Flame Ionization Detector as described by Ryan et al. (2007). Following conditions were used for the GC analysis: column, DB wax Capillary; 60.0 m ×0.25 mm ×0.25 l m; oven temperature programme, the column held initially at 60°C for 3 min after injection, then increased to 185°C with 10°C/m in heating ramp for 1 min and increased to200^{0}C with 5°C/min heating ramp for 10 min. Then the final temperature was increased to 220°C with 5°C/m in heating ramp for 20 min; injector temperature, 250°C; detector (FID) temperature, 275^{0}C; carrier gas, Nitrogen; inlet pressure, 40.65 psi; linear gas velocity, 39 cm/s; column flow rate , 2.7 ml/m in; split ratio, 40:1; injected volume, 1µL.

Volatile compounds analysis

Volatile compounds from sorghum and millet flours were extracted by using Clevenger apparatus according to the method of Damjan et al. (2009). In this method flour sample of 250g of sorghum and millet grains and 2 l distilled water was placed in a 4 l flask for 30 minutes. After that flour sample was transferred into Clavenger apparatus. Dichloromethane from Sigma Aldrich was used as the extraction solvent. The samples were heated for 4 hours. After that samples were cooled and dichloromethane was separated in flasks. After that dichloromethane was evaporated by using rotary evaporator. After evaporation the concentrated samples were transferred into vials having small amount of sodium sulphate. The samples were then subjected to GC (Agilent 6890) Coupled with Mass Detector (Agilent 5973).

Following specifications were used for the volatile analysis. Column: VOCOL, 60 m×0.25 mm (i.d.), film thickness 1.5µm (Supelco, Bellefonte, PA, USA). Temperature programmed as: starting at 50°C (2 min), heating at 5°C min^{-}1, final temperature 210°C (40 min). Tinj: 250°C; Tdet : 280°C; injection volume: 1µl. Carrier gas: He, flow 1 ml min^{-}1. MS conditions were set in a way that: electron impact mode, total ion current (TIC) recorded. NIST spectral library was used to compare the mass spectra of compounds subjected to analysis. Damjan et al., 2009).

Results and Discussion

Proximate composition

Chemical composition for different varieties of Sorghum and Millet have been shown in table 1 and table 2. The moisture content was ranged from 5.4 to 10.0% in different varieties of sorghum and 8.1 to 9.3% in millet varieties. Ash content ranged from 1.6 to 3.3% in sorghum and 1.5 to 2% in millet. Crude fat ranged from 2.5 to 5.6% in whole flour of different varieties of sorghum and 3.7 to 3.8% in millet. Crude fiber showed minimum value of 2.6% and the maximum value of 3.9% for sorghum. Crude fiber exhibited the minimum value of 2.2% and the maximum value of 2.9% for millet. Crude protein in different varieties of sorghum ranged from 11.9 to 17.0% and 15.7 to 16.1% in millet. Nitrogen free extract (NFE) in different varieties of sorghum was ranged from 64.9 to 69.7%. NFE in different varieties of millet was ranged from 67.3 to 66.8%.

Table 1 Mean Values for proximate of sorghum varieties

Sr.No.	Varieties	Moisture Contents	Ash Content	Fat Content	Fiber Content	Protein Content	(NFE)
1	F-114	10.0 [a]	1.8 [d]	3.3 [cd]	3.1 [bc]	12.6 [d]	69.7 [a]
2	Chengari	9.0 [b]	3.3 [a]	5.6 [a]	3.3 [ab]	11.9 [d]	66.6 [bc]
3	SB	8.6 [bc]	2.7 [ab]	2.5 [d]	3.2 [abc]	17.0 [a]	64.9 [c]
4	JS-263	8.3 [c]	1.6 [d]	4.5 [b]	3.9 [a]	15.3 [b]	66.3 [c]
5	MR	6.7 [d]	2.1 [cd]	4.7 [ab]	2.6 [c]	14.0 [c]	69.6 [a]
6	PC-1	6.7 [d]	3.0 [ab]	3.9 [bc]	3.0 [bc]	14.3 [bc]	68.8 [a]
7	JS-2002	5.4 [e]	2.6 [bc]	5.4 [a]	3.4 [ab]	14.5 [bc]	68.3 [ab]

Mean carrying same letters are significantly identical.

Table 2 Mean Values for proximate of millet varieties

Sr.No.	Varieties	Moisture Contents	Ash Content	Fat Content	Fiber Content	Protein Content	NFE
1	MB-87	9.3 [a]	1.5 [b]	3.7 [a]	2.2 [a]	15.7 [a]	67.3 [a]
2	S-2011	8.1 [b]	2.0 [a]	3.8 [a]	2.6 [c]	16.1 [a]	66.8 [a]

Mean carrying same letters are significantly identical.

Fatty acids analysis of millet and sorghum oil

Fatty acid analysis of oil from millet varieties: Fatty acids methyl esters of samples were loaded on a DB-WAX column, FID as detector and fractionated by "Gas Chromatography". Two varieties of millet i-e MB-87 and Sargodha Bajra-2011 were subjected to FAME analysis. The fatty acids composition of these two varieties of millet oil is presented in Table 3. The analysis has shown that the most abundant fatty acid found in both millet varieties is linoleic acid followed by oleic, palmitic and stearic acid. The fatty acid composition of S. Bajra-2011 includes linoleic acid, oleic acid, palmitic acid, erucic acid, stearic acid, arachidic acid, linolenic acid and myristic acid with their concentration in mg/g are as 30.38982, 16.04982, 6.319236, 2.19719, 1.402741, 0.111822, 0.404938 and 0.232085 respectively. Whereas the different fatty acids present in MB-87 includes linoleic acid, oleic acid, palmitic acid, behenic acid, stearic acid, linolenic acid, eicosaenoic acid, myristic acid arachidic acid and their concentration in mg/g are as 20.71603, 13.12652, 4.613243, 1.327375, 1.304543, 0.325811, 0.315462, 0.214316, respectively. Unsaturated fatty acids are more in concentration as compared to saturated fatty acids. Millet varieties are rich in concentration of mono and polyunsaturated fatty acids. The results obtained were in accordance to the research work of Liang et al. (2010) and Amadou et al. (2011).

Fatty acid analysis of oil from sorghum varieties: The following seven varieties of sorghum were subjected to fatty acid analysis. The varieties are MR-Sorghum, Sandal Bar, PC-1, JS-2002, JS-263, F-114 and Chengari. The fatty acids composition of these varieties is presented in Table 4. The analysis has shown that the most abundant fatty acid found in all varieties is linoleic acid followed by palmitic acid, oleic acid and stearic acid. The results obtained are in accordance with the research outcomes of Mehmood et al. (2008) and Abugri et al. (2013).

The fatty acid composition of Sandal Bar includes palmitic acid, linolenic acid, linoleic acid, oleic acid, stearic acid, palmitoleic acid, arachidic acid and with their concentration in mg/g are as 20.04547, 15.49279, 11.04548, 6.764472, 1.986131, 0.406898, 0.399018 respectively. Fatty acids present in Chengari includes linoleic acid, oleic acid, palmitic acid, stearic acid, linolenic acid, behenic acid, arachidic acid, palmitoleic acid and their concentration in mg/g are as 32.57048, 26.05815, 8.680313, 2.05107, 1.750787, 0.816, 0.642986, 0.268352 respectively. The results obtained are in accordance with the research outcomes of Mehmood et al. (2008) and Abugri et al. (2013).

However the fatty acid composition of PC-1includes palmitic acid, oleic acid, linolenic acid, linoleic acid, caprylic acid, stearic acid, palmitoleic acid, arachidic acid and with their concentration in mg/g are as 20.31206, 15.31234, 10.33762, 6.490962, 5.142434, 0.399018, 0.203304 respectively. The fatty acid composition of MR-Sorghum includes palmitic acid, linolenic acid, linoleic acid, oleic acid, stearic acid, palmitoleic acid, arachidic acid and with their concentration in mg/g are as 20.04547, 15.49279, 11.04548, 6.764472, 1.986131, 0.406898, 0.399018 respectively. The results obtained are in accordance with the research outcomes of Mehmood et al. (2008) and Abugri et al. (2013).

On the other hand fatty acid profile and concentration of JS-263 includes palmitic acid, linolenic acid, linoleic acid, oleic acid, lauric acid, tri-decanoic acid, behenic acid, stearic acid, palmitoleic acid, arachidic acid and with their concentration in mg/g are as 21.42487, 21.1333, 15.49279, 8.665198, 6.809967, 1.833253, 1.11989, 0.571411 and 0.106262 respectively. Fatty acids present in JS-2002 includes linoleic acid, oleic acid, palmitic acid, linolenic acid, pentadecanoic acid, heptadecanoic acid, behenic acid and their concentration in mg/g are as 10.11821, 8.665198, 6.319236, 6.293466, 2.861636, 1.468547, 1.327375 respectively. The results obtained are in accordance with the research outcomes of Mehmood et al. (2008) and Abugri et al. (2013).

Table 3 Fatty acid composition of Millet varieties

Serial No.	Fatty acid	Carbon #	MB-87	S.Bajra 2011
1	Caprylic acid	C:8	--	--
2	Capric acid	C:10	--	--
3	Lauric acid	C:12	--	--
4	Tri-decanoic acid	C:13	--	--
5	Myristic acid	C:14	0.315462	0.232085
6	Myristoleic acid	C:14:1	--	--
7	Pentadecanoic acid	C:15:0	--	--
8	Palmitic acid	C:16:0	4.613243	6.319236
9	Palmitoleic acid	C:16:1	--	--
10	Heptadecanoic acid	C:17:0	--	--
11	Stearic acid	C:18:0	1.304543	1.402741
12	Oleic acid	C:18:2	13.12652	16.04982
13	Linoleic acid	C:18:2	20.71603	30.38982
14	Arachidic acid	C:20:0	0.111822	0.111822
15	Eicosaenoic acid	C:20:1	0.214316	0.226012
16	Linolenic acid	C:18:3	0.325811	0.404938
17	Behenic acid	C:22:0	1.327375	--
18	Erucic acid	C:22:1	--	2.19719

"--"= Not detected

Table 4 Fatty acid contents of different sorghum varieties

Serial No.	Fatty acid	Carbon #	Chengari	JS-2002	JS-263	F-114	PC-1	MR-Sorghum	Sandal Bar
1	Caprylic acid	C:8	--	--	--	--	6.490962	--	--
2	Capric acid	C:10	--	--	--	--	--	--	--
3	Lauric acid	C:12	--	--	6.809967	--	--	--	--
4	Tri-decanoic acid	C:13	--	--	1.833253	--	--	--	--
5	Myristic acid	C:14	--	--	--	--	--	--	--
6	Myristoleic acid	C:14:1	--	5.853584	--	--	--	--	--
7	Pentadecanoic acid	C:15:0	--	2.861636	--	--	--	--	--
8	Palmitic acid	C:16:0	8.680313	6.319236	21.42487	7.68082	20.31206	20.04547	20.28759
9	Palmitoleic acid	C:16:1	0.268352	--	0.106262	0.268352	0.399018	0.399018	--
10	Heptadecanoic acid	C:17:0	--	1.468547	--	--	--	--	--
11	Stearic acid	C:18:0	2.05107	--	0.571411	2.05107	5.142434	1.986131	3.187229
12	Oleic acid	C:18:2	26.05815	8.665198	8.665198	0.109203	15.31234	6.764472	24.90237
13	Linoleic acid	C:18:2	32.57048	10.11821	21.1333	13.11945	10.33762	11.04548	40.37136
14	Arachidic acid	C:20:0	0.642986	--	--	0.764418	0.203304	0.406898	0.406898
15	Eicosaenoic acid	C:20:1	1.442999	--	--	3.2255	1.566329	--	0.303668
16	Linolenic acid	C:18:3	1.750787	6.293466	15.49279	0.387244	--	15.49279	0.407188
17	Behenic acid	C:22:0	0.816	1.327375	1.11989	--	--	--	--
18	Erucic acid	C:22:1	--	--	--	--	--	--	--

Fatty acids present in F-114 includes linoleic acid, palmitic acid, eicosaenoic acid, stearic acid, arachidic acid, linolenic acid, palmitoleic acid, oleic acid their concentration in mg/g are as 13.11945, 7.68082, 3.2255, 2.05107, 0.764418, 0.387244, 0.268352, 0.109203 respectively. The results obtained are in accordance with the research outcomes of Mehmood et al. (2008) and Abugri et al. (2013).

Volatile compounds of sorghum and millet

The volatile compounds from Sorghum and millet varieties were extracted by using the Clevenger apparatus method and detected by using GC-MS. The results obtained were identified from NIST library. A total of 30 volatile compounds were identified in millet varieties. These compounds included aldehydes, benzene derivatives, ketones, alcohols, esters, hydrocarbons, acids, furans and S-containing compounds. On the other hand 35 volatiles compounds were identified in seven varieties of sorghum. The results are presented in below in respected Table 5 & 6 of Millet and Sorghum.

Volatile compounds of millet: Aldehydes were the main compounds present in both the varieties namely MB-87 and S.Bajra 2011. Main compounds that were found were hexanal, heptanal, 2,4-Heptadienal, nonanal, 2,4-Decadienal, tridecanal. Benzene derivitves that were identified include 1,2,4,5-tetramethylbenzene, 2-Methylnaphthalene, 1,6-Dimethylnaphthalene, phenanthrene. Alcohols that were discovered include 1-Hexanol, 1-Octen-3-ol, 1-Octanol, 8-Dodecen-1-ol. Ketonic compounds that were identified include 2-heptanone, 2,5-octanedione, acetophenone, 3 nonen-2-one, 2-heptadecanone. Main hydrocarbon compounds that were discovered are dodecane, tridecane, hexadecane, octadecane. Acidic compounds that were distinguished include Tetradecanoic acid, pentadecanoic acid, hexadecanoic acid. Main ester compounds that were

identified include Propyl benzoate, Benzoic acid, butyl ester, Hexadecanoic acid, methyl ester. Heterocycles that were identified includes 3-Furaldehyde, Furfural, 1-(2-Furanyl)-ethanone, 2 Pentylfuran. Sulphur containing compounds that were present include Diethyl disulphide, Benzothiazole. The results that were obtained were in accordance to the research outcomes of Damjan et al. (2009) and Liu et al. (2012).

Volatile compounds of sorghum: Aldehydes were the main compounds present in all the varieties namely Chengari, JS-2002, JS-263, F-114, PC-1, MR-Sorghum and Sandal Bar. Main compounds that were found were hexanal, heptanal, 2,4-Heptadienal, nonanal, decanal and tridecanal. Benzene derivitves that were identified include 1,2,4,5-tetramethylbenzene, 2-Methylnaphthalene, m-xylene, phenanthrene and toluene. Alcohols that were discovered include Propan-1-ol, 1-Hexanol, 2,3-Butanediol, 1-Octanol and nonan-1-ol. Ketonic compounds that were identified include 2-heptanone, 2,5-octanedione, 3 nonen-2-one. Main hydrocarbon compounds that were discovered are dodecane, tridecane, hexadecane, octadecane. Acidic compounds that were distinguished include Tetradecanoic acid, acetic acid, hexadecanoic acid and isobutyric acid. Main ester compounds that were identified include Propyl benzoate, ethyl acetate andpropyl acetate. Heterocycles that were identified includes 3-Furaldehyde, Furfural and 2 Pentylfuran. Sulphur containing compounds that were present include Diethyl sulfide and diethyl disulphide. The results that were obtained were in accordance to the research outcomes of Lasekan et al. (1997) and Lyumugabe et al. (2013).

Table 5 Volatile compounds of millet varieties

		Retention times	
Serial No.	Compound name	MB-87	S. Bajra 2011
	Aldehydes		
1	Hexanal	21.798	22.103
2	Heptanal	--	17.557
3	(E,E)-2,4-Heptadienal	14.911	15.334
4	Nonanal	16.748	--
5	(E,E)-2,4-Decadienal	--	20.459
6	Tridecanal	17.89	--
	Benzene derivatives		
1	1,2,4,5-Tetramethylbenzene	23.784	23.946
2	2-Methylnaphthalene	--	25.079
3	Phenanthrene	26.038	25.166
	Alcohols		
1	1-Hexanol	24.170	--
2	1-Octen-3-ol	23.298	23.734
3	1-Octanol	--	23.852
	Ketones		
1	2-Heptanone	26.287	--
2	2,5-Octanedione	26.991	27.520
3	Acetophenone	29.338	28.609
4	3-Nonen-2-one	--	29.662
	Hydrocarbons		
1	Dodecane	31.361	32.071
2	Tridecane	33.410	--
3	Hexadecane	34.079	34.823
	Acids		
1	Tetradecanoic acid	35.789	--
2	Pentadecanoic acid	--	34.612
3	Hexadecanoic acid	10.054	8.454
	Esters		
1	Propyl benzoate	--	13.043
2	Benzoic acid, butyl ester	9.575	--
3	Hexadecanoic acid, methyl ester	5.397	5.908
	Heterocycles		
1	3-Furaldehyde	3.280	3.952
2	Furfural	--	2.321
3	1-(2-Furanyl)-ethanone	1.680	1.113
	Sulphur-containing		
1	Diethyl disulphide	1.742	--
2	Benzothiazole	1.649	4.089

"--"=Not detected

Table 6: Volatile compounds of sorghum varieties

Sr. No.	Compound name	Retention times (min)						
		Chengari	JS-2002	JS-263	F-114	PC-1	MR-Sorghum	Sandal Bar
	Aldehydes							
1	Hexanal	3.330	3.716	3.821	4.220	4.961	5.085	5.160
2	Heptanal	6.150	6.219	6.312	6.387	6.511	6.841	6.916
3	(E,E)-2,4-Heptadienal	7.053	7.178	8.927	9.363	9.668	9.730	10.179
4	Nonanal	11.953	12.532	12.819	13.068	13.199	13.622	14.045
5	Decanal	14.195	14.487	14.799	15.085	15.384	15.677	15.851
6	Tridecanal	16.231	16.511	16.585	16.872	16.997	17.059	17.408
	Benzene derivatives							
1	1,2,4,5-Tetramethylbenzene	17.582	17.607	17.682	18.049	18.136	18.834	18.915
2	2-Methylnaphthalene	19.768	20.029	20.309	20.527	20.577	21.150	21.586
3	rn-Xylene	21.660	22.215	22.700	23.454	23.883	25.447	26.206
4	Phenanthrene	26.984	28.161	28.752	30.197	31.654	33.111	33.323
5	Toluene	34.294	34.543	34.674	35.072	35.521	33.250	33.750
	Alcohols							
1	Propan-1-ol	2.240	2.321	2.794	3.137	3.280	3.772	3.952
2	1-Hexanol	4.295	5.291	5.397	5.908	5.976	7.159	7.937
3	2,3-Butanediol	8.105	8.454	8.759	9.450	9.575	10.372	11.374
4	Octan-1-ol	12.526	13.043	14.706	15.334	15.864	16.412	16.748
5	Nonan-1-ol	16.904	17.557	18.049	18.311	20.204	21.144	21.536
	Ketones							
1	2-Heptanone	21.686	21.729	21.959	22.171	22.277	23.298	23.529
2	2,5-Octanedione	24.108	24.326	24.456	24.699	24.973	25.079	25.278
3	3-Nonen-2-one	26.287	26.474	26.991	27.520	28.609	29.338	29.711
	Hydrocarbons							
1	Dodecane	30.241	30.901	31.187	31.361	32.071	32.725	33.092
2	Tridecane	33.410	33.535	34.107	34.823	35.079	35.216	35.789
3	Hexadecane	36.125	36.417	36.884	35.250	36.250	36.653	36.750
4	Octadecane	1.150	1.325	1.343	1.991	2.052	2.190	3.716
	Acids							
1	Tetradecanoic acid	4.220	4.961	5.085	5.932	6.088	6.219	6.387
2	Acetic acid	6.511	6.841	6.916	7.178	8.927	9.363	10.179
3	Hexadecanoic acid	10.876	11.953	12.532	12.819	13.068	13.199	13.622
4	Isobutyric acid	14.120	14.276	14.487	14.649	15.085	15.633	15.714
	Esters							
1	Propyl benzoate	15.851	15.982	16.125	16.331	16.586	16.760	16.953
2	Ethyl acetate	17.364	17.408	17.607	17.682	18.049	18.136	18.834
3	Propyl acetate	19.450	19.531	19.680	20.029	20.527	20.776	20.944
	Heterocycles							
1	3-Furaldehyde	21.287	21.586	21.660	22.127	22.420	22.700	23.211
2	Furfural	24.338	25.447	26.411	26.984	28.161	28.752	29.823
3	2-Pentylfuran	30.197	31.224	31.934	32.420	33.111	33.572	34.294
	Sulphur-containing							
1	Dimethyl sulfide	34.674	35.072	35.521	31.750	34.770	33.250	34.570
2	Diethyl disulphide	35.520	36.778	36.342	33.768	35.763	34.543	35.250

Conclusion

Sorghum and millet are neglected cereals and can become important staple crops not only for the under developed, drought and famine affected countries but can also for the developed countries. Sorghum and millet characterization have depicted that these have nutritional profile comparable to wheat and other cereals. In fact these are the good and effective sources of proteins, fiber, fatty acid and many other nutritional components. In this research fatty acid profile of sorghum and millet showed that these are rich in palmitic acid, oleic acid, linolenic and linoleic acid, stearic acid, myristic acid, behenic acid, erucic acid. The volatile profile of sorghum and millet have shown that these belong to the various aromatic groups, aliphatic, sulpher groups, acids, aldehydic, ketonic, benzene derivatives, esters and hydrocarbons. Thus these two important and potent cereals have to be prioritized and given the due attention in using as staple as well as in drought and famine conditions.

Acknowledgement

Special thanks to Higher Education Commission for funding this research project under National research Programme for Universities (NRPU).

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