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Research Article

Nutrition and fatty acid composition in different botanical groups of groundnut (*Arachis hypogaea*. L) in ICRISAT mini core collection

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Abstract
Breeding for enhanced nutritional quality is need of the hour. India not only needs increased quantity of food to feed the growing population but also quality food to mitigate hidden hunger. Oil is the major energy source of the Indian diet. Chemical composition of oil decides its edible nature. Even in edible oil fatty acid composition in general and ratio of oleic acid to linoleic acid of the oil plays major role in deciding its quality. In India, availability of breeding line to improve groundnut oil quality is limited. Screening of different botanical group may give some idea about choice of material for further crop improvement program. In present study botanical group *hypogaea,* found to have higher amount of oleic acid and *fastigiata* group recorded high protein and oil content. Growing season also matters in the expression of different fatty acid. *Rainy* season is found to have better for the better expression of all studied traits.

Key words:
Groundnut, oleic acid, protein, oil, botanical variety

Introduction:

Groundnut is one of the most important oilseed crops in India. It is a rich source of protein (44 – 56 %), oil (22 – 30 %), vitamins and minerals, hence it is called as poor-mans almond. Groundnut oil generally contains 45-50 per cent mono-unsaturated fatty acids, 30-35 per cent poly unsaturated fatty acids and 17-18 per cent of saturated fatty acids (Ory *et al.*, 1992). Poly-unsaturated fatty acids have high potential of developing off-flavors due to oxidation. Oxidation of linoleic and linolenic acid is approximately 10 and 25 times higher, respectively, than that of oleic acid (Frankel, 1991, Lands, 1997). Oil with higher ratios of oleic to linoleic acid retains its quality longer in seed or as oil. Hence, fatty acid composition of groundnut oil determines its quality. Proportion of oil and protein content decides the nutritive value and usage of groundnut. Genotype with high oil content and low protein content are used in oil extraction and individuals with high protein content with low oil are preferred for confectionary purpose. Botanically cultivated groundnut can be classified in to two sub species and six botanical types or varieties. Genetic improvement is possible when we harvest the advantages of these different groups. There exists genotypic difference for nutritional and oil quality traits. By and large if breeder identifies at least botanical group which gives advantage for selecting the better genotype then program for introgression becomes very easy. Looking to the requirement and availability of the material one can plan a good breeding strategy to combine the desirable traits in single genotype. Hence, it is necessary to identify the botanical group which has oil quality advantage over other group.

Material and methods

The groundnut mini core collection, consisting of 184 germplasm accessions selected from 1704 core collection accessions, representing the global germplasm of 14,310 accessions maintained at ICRISAT gene bank (Upadhyaya et al., 2002) was utilized in the present investigation. The mini core collection consisted of 37 subsp. *fastigiata* var. *fastigiata*, 58 subsp. *fastigiata* var. *vulgaris* Harz, two subsp. *fastigiata* var. *peruviana* Krapov. & W. C. Greg., and one subsp. *Fastigiata* var. *aequatoriana* Krapov. & W. C. Greg.,85 subsp. *hypogaea* var. *hypogaea* and one subsp. *hypogaea* var. *hirsuta* J. Kohler. The four control cultivars used in the study were M 13, ICGS 76 (both subsp. *hypogaea* var. *hypogaea*), ICGS 44 (subsp. *fastigiata* var. *vulgaris*), and Gangapuri (subsp. *fastigiata* var. *fastigiata*). M 13 and Gangapuri are cultivars developed by the national research centres whereas ICGS 44 (ICGV 87128 [PI 537112]) and ICGS 76 (ICGV 87141 [PI 546372]) are high-yielding cultivars developed at ICRISAT and released for cultivation in India. These 188 genotypes were evaluated in randomized block design with two replications in the 2008 rainy and 2008/2009 post-rainy seasons at the University of Agricultural Sciences (UAS), Dharwad, India, in vertisol fields and at ICRISAT, Hyderabad in alfisol fields. The blocking within the replication was done to minimise the effect of soil heterogeneity. Geographically Dharwad is located at 75°07’ E, 15°13’ N, and 678 m above mean sea level, whereas, ICRISAT is located at 17^0 24 north, longitude of 78^0 12 east and altitude of 536 m above mean sea level.

Each genotype was grown in one row of 2.5 meter length with the spacing of 45 cm between row and 10 cm between plants. All required agronomic practices and plant protection measures against pests and diseases to raise a successful crop were followed.

Phenotyping by Near Infra-Red Spectrophotometer
Total protein content, oil content and fatty acid composition were estimated using Near Infra-Red spectrophotometer (NIRS) (Panford, 1990; Mishra et al., 2000). A random sample of 100 seeds was used to record protein and oil content in percentage. A total of five randomly selected well matured kernels from each replication were used for the estimation of fatty acid composition. Eight fatty acids *viz.,* Palmitic acid (16:0), Stearic acid (18:0), Oleic acid (18:1), Linoleic acid (18:2), Arachidic acid (20:0), Eicosenoic acid (20:1), Behenic acid (22:0) and Lignoceric acid (24:0) were quantified using NIRs. Among these Palmitic, Stearic, Arachidic, Behenic and Lignoceric acids are saturated fatty acid with no double bonds in their fatty acid chain and Oleic and Eicosenoic acids are monounsaturated fatty acids with single double bond and the Linoleic acid is the polyunsaturated fatty acid with two double bonds in their fatty acid chain. The value in the brackets indicates the number of carbon atoms and the number of double bonds in the fatty acid chain.

Oil stability indices *viz.,* Oleic acid/Linolec acid (O/L ratio), Iodine value (IV) unsaturated/saturated (U/S) fatty acid and per cent of standard fatty acids (%S) were estimated as follows.

a) Oleic/Linoleic acid: Per cent of Oleic acid (18:1)/per cent of Linoleic acid (18:2).
b) Iodine value (IV): (% Oleic acid x 0.8601) + (% Linoleic acid x 1.7321) + (% Eicosenoic acid x 0.7854) (Mozingo *et al.,* 1988).
c) Unsaturated/saturated fatty acid (U/S): % (Oleic acid + Linoleic acid + Eicosenoic acid) % (Palmitic acid + Stearic acid + Arachidic acid + Behenic acid + Lignoceric acid).
d) Total saturated fatty acid (%): (Palmitic acid + Stearic acid + Arachidic acid + Behenic acid + Lignoceric acid) (Mozingo *et al.,* 1988).

Results and Discussion
The analysis of variance for different traits revealed highly significant differences for the traits studied among the genotypes, suggesting presence of high degree of genetic variability in the material evaluated (Table 1). This could be attributed to their divergent pedigree, origin and different botanical groups of germplasm lines.

Performance of different botanical groups in mini core collection: Botanically cultivated groundnut can be classified into two subspecies which mainly differ in their branching pattern, subspecies *hypogaea* with alternate branching and subspecies *fastigiata* with sequential branching habit. These subspecies have six botanical varieties, subspecies *hypogaea* has var. *hypogaea* (Virginia) and var *hirsuta* and subspecies *fastigiata* has var. *fastigiata* (Valencia), var. *vulgaris* (Spanish), var. *peruviana* and var. *aequatoriana*. To identify the botanical group suitable for exploiting desirable combination of traits, mini core collection were classified into four botanical groups *viz.,* Spanish Bunch, Valencia, Virgina Runner and Virginia Bunch (Table 2). Spanish Bunch type recorded relatively higher protein content followed by Virginia and Valencia group. Whereas, spp. *fastigiata* accessions had high mean oil content compared to spp. *hypogaea* group (Fig. 1). Expression of these quality traits was also affected by location and season (Upadhyaya, 2003). Mean protein content of the mini core was slightly high when it was grown in *Rainy* season (23.87%) compared to post-rainy season (23.40%). However, at ICRISAT, Hyderabad still higher protein content (25.01%) was observed compared to UAS Dharwad location. Mean oil content was more in post-rainy season (46.28%) compared to *Rainy* season (45.75%). However, there was not much difference between the locations which implies the role of season on the expression of trait (Table 4).

Palmitic acid content was comparatively higher in Spanish Bunch accessions(11.06%) followed by Valencia group and Virginia. In *Rainy* season, mini core collection recorded less palmitic acid content (10.71%) compared to post-rainy season (10.89%). Dharwad location was favourable to record higher mean values of palmitic acid (positive environmental index) in mini core collection as compared to ICRISAT, Hyderabad location (negative environmental index) (Table 3). The spp. *hypogaea* accessions had relatively higher oleic acid (54.80%) and less linoleic acid (25.90%) compared to spp. *fastigiata* accessions. This was also reflected interms of O/L ratio in spp. *hypogaea* and spp. *fastigiata* accessions. Among the botanical varieties, oleic acid was relatively higher in accessions belonging to Virginia Runner (55.64%), followed by Virginia Bunch (53.97%), Valencia (48.93%) and less in Spanish Bunch type (45.85%). Virginia Runner accessions had a higher oleic/linoleic acid ratio and low iodine value indicating a longer shelf-life (Table 2). Similar observations were recorded by Bansal *et al.* (1993).The genotypes with Spanish bunch growth habit recorded relatively higher linoleic acid content and can be used as a source of refined oil (Bansal *et al.,* 1993). For better expression of all these fatty acid traits, *rainy* season was found to be good as it exhibited positive environmental index. The spp. *hypogaea* and *fastigiata* did not differ much in minor fatty acids *viz.,* arachidic acid, eicosenoic acid, behenic acid and lignoceric acid content.

Iodine value which is the indicator of degree of saturation was more in spp. *fastigiata* group. Low iodine number implies the few unsaturated bonds and hence, low susceptibility to oxidative rancidity (Aruna and Nigam, 2009). Accessions belonging to spp. *hypogaea* had this advantage with less total saturated fatty acids compared to spp. *fastigiata* accessions. Seasonal effect on this trait was less compared to location effect.

Nutritional and oil quality breeding is the need of the hour to tackle growing problem of hidden hunger in India. Introgression breeding can be undertaken by choosing the genotype with high oleic acid. The information on nutritional and oil quality traits in different botanical groups gives the key idea to select the best botanical group to start genetic improvement of these traits. From the study of botanical group, Virginia found to have desirable characters and breeder can screen the genotypes of this group and utilize the best genotypes for crop improvement programs.

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Table 1. ANOVA for protein, oil and fatty acid composition of mini core collection

Source of variation	Location/ season	df	Protein (%)	Oil (%)	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Arachidic acid (%)	Ecosenoic acid (%)	Behenic acid (%)	Lignoceric acid (%)	O/L ratio	Iodine value	Unsaturated /saturated fatty acid ratio	Total saturated fatty acid (%)
Replication	E_1S_1	1	0.55	5.55	0.56	0.11	1.07	0.41	0.01	0.02	0.02	0.03	0.03	0.04	0.06	0.81
	E_1S_2		8.66	11.33	11.56	1.98*	51.32	25.56	1.16	0.01	1.99	0.78	0.44	6.64	0.24*	2.88
	Pooled		50.52	8.33	7.72	0.58	28.10	13.82	0.57	0.03	1.07	0.40	2.60	34.94	1.60	1.96
	E_2S_1	1	4.4	17.22	0.66	2.97	5.04**	7.38	4.89**	0.63**	2.35**	0.09**	2.44*	44.90	17.05**	64.45**
Genotypes	E_1S_1	195	63.87**	12.77**	2.10**	1.50**	154.11**	93.64**	0.09**	0.03	0.49**	0.04*	1.92**	40.85**	0.61**	7.05**
	E_1S_2		52.64**	7.57**	1.83*	1.27**	125.43**	76.87**	0.10*	0.03**	0.34	0.36*	1.50**	33.49**	0.48**	6.12**
	Pooled		67.67**	10.46**	2.15**	1.67**	150.86**	89.68**	0.10**	0.03*	0.49*	0.05	1.73**	38.17**	0.66*	8.02**
	E_2S_1	188	26.46**	13.50**	1.17**	1.14	92.51**	52.97**	0.18**	0.03**	0.42**	0.04**	1.15**	42.79**	0.34**	4.37**
Season	Pooled	1	10.52	0.98	0.30	0.98	0.76	0.23	0.06	0.02	0.02	0.01	0.02	0.01	0.03	0.57
G x E interactions	Pooled	1	6.90	3.95	0.29	0.71	0.08	0.55	0.05	0.01	0.02	0.01	0.01	1.11	0.02	0.65
Error	E_1S_1	195	1.05	1.05	0.40	0.40	1.25	1.06	0.06	0.04	0.01	0.03	0.02	1.63	0.02	0.90
	E_1S_2		5.18	3.13	0.32	0.18	17.73	11.64	0.03	0.00	0.07	0.01	0.20	5.98	0.06	0.79
	Pooled	588	18.46	4.83	7.30	0.44	50.05	31.59	0.40	0.01	0.40	0.30	0.69	14.70	0.57	2.05
	E_2S_1	188	1.91	4.57	0.29	1.80	0.08	7.62	0.03	0.01	0.07	0.01	0.10	22.95	0.02	0.54

Table 2. Mean performance of different botanical groups of groundnut germplasm collections

Characters	Spanish Bunch	Valencia	Mean *fastigiata*	Virginia Runner	Virginia Bunch	Mean *hypogaea*
Protein (%)	27.08	19.64	23.36	23.43	21.91	22.67
Oil (%)	46.53	47.23	46.88	44.21	44.17	44.19
Palmitic acid (%)	11.06	10.88	10.97	10.17	10.27	10.22
Stearic acid (%)	3.24	2.16	2.7	2.50	2.53	2.52
Oleic acid (%)	45.85	48.93	47.39	55.64	53.97	54.80
Linoleic acid (%)	32.68	31.09	31.88	24.99	26.81	25.90
Arachidic acid (%)	1.18	1.01	1.095	1.02	1.02	1.02
Eicosenoic acid (%)	1.00	1.15	1.075	1.11	1.10	1.10
Behenic acid (%)	3.76	3.53	3.64	3.15	3.27	3.21
Lignoceric acid (%)	1.19	1.37	1.28	1.31	1.30	1.30
O/L ratio	1.52	1.79	1.65	2.48	2.21	2.34
Iodine value	96.83	96.83	96.83	92.01	93.72	92.86
Unsaturated/saturated fatty acid	3.93	4.31	4.12	4.56	4.48	4.52
Total saturated fatty acid (%)	20.43	18.96	19.69	18.15	18.40	18.27

Table 3.Environmental indices for mini core collection grown over three locations

Characters	UAS, Dharwad		ICRISAT, Hyderabad
	***Rainy* 2008**	**Post-rainy 2008-09**	***Rainy* 2008**
Protein (%)	-0.264	-0.754	1.017
Oil (%)	-0.329	0.232	0.097
Palmitic acid (%)	0.262	0.439	-0.701
Stearic acid (%)	-0.092	-0.167	0.26
Oleic acid (%)	0.343	1.515	-1.858
Linoleic acid (%)	1.153	1.988	-3.141
Arachidic acid (%)	-0.163	-0.106	0.27
Ecosenoic acid (%)	0.01	0.007	-0.016
Behenic acid (%)	-0.093	-0.02	0.113
Lignoceric acid (%)	-0.042	0.003	0.039
O/L ratio	-0.107	0.005	0.103
Iodine value	3.307	3.744	-7.051
Unsaturated/saturated fatty acid ratio	0.173	0.093	-0.266
Total saturated fatty acid (%)	-0.129	0.149	-0.02

Table 4. Mean and range for nutritional and oil quality traits in mini core collection

Mini core	Protein (%)		Oil (%)		Palmitic acid (%)		Stearic acid (%)		Oleic acid (%)		Linoleic acid (%)		Arachidic acid (%)	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
UASD Rainy 2008	23.87	12.73-33.6	45.75	39.64-52.10	10.71	7.10-12.40	2.73	0.80-4.30	50.05	33.40-73.6	29.67	10.4-43.97	1.08	0.5-1.67
UASD Post-rainy 2008-09	23.40	12.9-32.20	46.28	39.57-51.68	10.89	7.06-12.55	2.66	0.84-4.14	48.92	33.8-74.21	30.47	10.58-43.51	1.13	0.54-1.72
ICRISAT *Rainy* 2008	25.01	13.19-31.67	46.15	34.78-52.26	9.73	7.36-11.50	3.08	1.13-4.76	46.77	30.27-72.07	25.26	12.16-37.13	1.50	0.9-2.35

Mini core	Ecosenoic acid (%)		Behenic acid (%)		Lignoceric acid (%)		O/L ratio		Iodine value		Unsaturated/ saturated fatty acid ratio		Total saturated fatty acid (%)	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
UASD Rainy 2008	1.07	0.8-1.40	3.48	2.02-4.67	1.27	0.95-1.62	1.9	0.8-7.04	95.29	82.54-105.50	4.24	3.43-6.10	19.26	14.2-22.7
UASD Post-rainy 2008-09	1.07	0.8-1.34	3.55	2.34-4.60	1.31	0.96-1.66	1.79	0.8-7.11	95.70	82.46-105.50	4.16	3.42-5.66	19.54	15.03-22.84
ICRISAT *Rainy* 2008	1.04	0.8-1.50	3.68	2.34-4.99	1.35	1.02-1.73	2.05	0.85-6.0	84.81	72.8-101.28	3.81	2.91-5.08	19.36	14.89-23.24