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Assessment of variability in physical and chemical composition of *Cuminum cyminum* seeds from arid and semiarid India

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ABSTRACT

Cumin (*Cuminum cyminum* L.) is an important spice commodity cultivated under large areas in arid and semiarid India. It has attained a valuable importance due to its immense aromatic, culinary and medicinal values. Due to its very selective dry and cool climate requirement, cumin is mainly being grown in western regions of India. The present study accounts for the variability observed in physical and chemical properties of cumin seed samples collected from cumin growing areas located in the 7 districts of Rajasthan and 5 districts of Gujarat classified under Agro-Ecological Sub Regions (AESR) of India. Quantity of essential oil (EO) in cumin seeds from various districts revealed that the overall EO content ranged between 28.4 to 39.1 g/kg. In Rajasthan, highest EO content was recorded in the cumin samples from Nagaur (38.5 ± 0.37), followed by Jaisalmer (37.4 ± 0.31) and was least in Ajmer (28.6 ± 0.27) whereas, in Gujarat, samples from Patan possessed highest EO content (39.1± 0.17) with least values in Amreli (28.4 ±1.08). The average flavonoid content expressed as mg QE/g seeds was highest in Nagaur (39.72), followed by Amreli (36.03) and lowest in Ajmer district (23.71), similarly the estimated phenol content (mg GAE/g seeds) was maximum in Jalore (73.61), followed by Nagaur (63.77) and least in Amreli district (41.50). The carbohydrates content and total protein content ranged between 15.86-28.88 and 19.30-21.89 per cent respectively. This study also provides basic information in understanding cumin composition and its value as a commodity for business based on interstices parameters reflecting quality assessment for regional produce harvested from India.

Key words: Agro ecological sub regions, Cumin, Essential oil, Nutrient composition, Spices, Total flavonoids, Total phenols

Cumin (*Cuminum cyminum* L.) is an annual herbaceous plant belonging to the Apiaceae family, highly sensitive to humidity and temperature fluctuations. It is cultivated in India during winter (*rabi* crop) and is a most commonly used spice/condiment in food and savouries, aroma extracts and medicinal commodity (Agrawal 2000, Pande and Goswami 2000). The latest estimates predict cumin contribution to exceed more than 10% in entire spice exports from India, both in terms of quantity and value. India's agro-climatic environment is highly congenial for producing premier quality cumin seed which is also depicted by world market demand for Indian cumin. National scenario for area and production of cumin respectively accounts to 3.7 mha and 2.8 m tonnes in Rajasthan and 3.2 mha and 1.65 m tonnes in Gujarat (Spice Board of India 2013). It's the first choice as a winter cash crop for farmers from arid and semi arid regions from Gujarat and Rajasthan.

As mentioned above, these cumin growing areas of India are classified under the Agro-Ecological Sub Regions (AESR) 2.1, 2.3, 2.4, 4.2 and 5.1. Biochemical profile of cumin seed and chemical composition of cumin essential oil in India has been reported earlier by some researchers (Agrawal 1996, Pande and Goswami 2000 and Sharma *et al.* 2016) depicting its status. The constituents of essential oil are dependent upon several intrinsic and extrinsic parameters affecting the plant genetic makeup, ecological situations and agricultural practices (Telci *et al.* 2009).

In cumin, earlier studies were mainly focussed on essential oil content and antioxidants potential of some varieties cultivated in India and Middle East. The present study was undertaken, taking into account the established facts of genotype and environment interaction on the biochemical composition of cumin. Study of commodity quality with respect to cultivating environment/region is essential to know its value as influenced by location in general. In the ongoing script we hereby comprehensively evaluate the morphometric, physical, chemical and nutritional properties of cumin expressed over India's agro-climate characterized on basis of agro ecological sub regions (Velayutham *et al.* 1999).

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MATERIALS AND METHODS

Under the present investigation, cumin physico-chemical profiles were generated for specifically collected seed samples from farmers' fields localized in cumin cultivating area of Ajmer, Barmer, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali districts of Rajasthan and Banaskantha, Kuchchh, Patan, Surendranagar and Amreli districts of Gujarat after harvest in the first week of April, 2016. Sample collection sites were tagged with global positioning system, GPS Map78s, Garmin of Taiwan and are presented in Table 1.

India has been mapped under 20 Agro-Ecological Regions (AER) and 60 Agro-Ecological Sub Regions (AESRs). Cumin is only cultivated in the conducive arid and semi arid tract of Rajasthan and Gujarat covered under the AESRs 2.1 (Marusthali hot, hyper arid Rajasthan) 2.3 (Rajasthan Bagar, North Gujarat Plain), 2.4 (South Kuchchh and North Kathiawar), 4.2 (North Gujarat Plain, some parts of Aravalli range and East Rajasthan) and 5.1 (Central Kathiawar Peninsula). Thussamples from the 12 cumin producing districts of Rajasthan and Gujarat (Table 1) were collected and processed for further studies.

Cumin seeds (60g) were finely ground in an electric grinder (Morphy Richards, Icon DLX) for each sample. Minimum three samples from each district were ground and three replicates were subjected to hydro-distillation for 6 h using Clevenger apparatus. The separated oil phase was dried over anhydrous sodium sulphate and stored in amber coloured glass bottle at 4°C till further analysis.

Seed samples were digested as per standard method using $HCl\text{-}HClO_4$ acid mixture in appropriate ratio to prepare the extract for the analysis of mineral components. After filtration the extracts were stored at 4°C for the mineral components analysis. Samples were analysed as per Page *et al.* (1982) for Cu, Zn, Fe, Mn, Ca, Mg, Na, S, N, P, K, protein and carbohydrates.

The total phenolic content (TPC) of cumin seed methanolic extract was estimated by Folin-Ciocalteu reagent according to method of Cetkovic *et al.* (2008). The absorbance of the extract was recorded at 760 nm after 2 h incubation at room temperature on a UV-VIS Spectrophotometer (UVWIN 5.0). The TPC was calculated on the basis of gallic acid calibration curve. The results were expressed as mg gallic acid equivalents/g (mg GAE/g) of sample.

Total flavonoid content of cumin seed methanolic extract was determined using standard protocol (Chang *et al.* 2002). The reaction mixture stored for 30 min. developed stable yellow colour at room temperature, which was estimated by spectrophotometric absorbance at 510 nm. Standard curve of Quercetin prepared with respective solvent having R^2 0.96-0.99 was used for calculation of total flavonoid content which was expressed as mg Quercetin equivalents (QE)/ g seeds.

All analyses were carried out in triplicates and results expressed as means. The data was analysed in Microsoft Excel (Microsoft Inc.). Significant differences between means were analyzed using analysis of variance (ANOVA) as per Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Cumin seed physical characteristics

Studies on cumin seed physical traits, viz. shape, colour and ridges are scanty. In the studied samples, colour of cumin seeds as noted on the basis of Munsell notations (Table 2) depicted a colour range variation within samples, which may have been influenced by stage of harvesting also. Colour ranged from very dark grey to dark grey, dark brown to greyish brown, yellowish brown and brown; non-significantly correlated and non-informative for AESR's association towards seed colour. The characteristic ridges on seed surface varied between 5 to 8 in number, minimum

Table 1 Location of the cumin samples studied

District	Location and co-ordinates	Elevation (MSL)	*Temperature (°C)		*Mean rainfall (mm)
			Min.	Max.	
Jodhpur	27° 06' 08" N, 72 ° 19' 85" E to27° 13'38" N, 72 ° 49' 23" E	271-286	12.59	29.44	344.2
Jaisalmer	26° 33' 75" N, 71 ° 05' 58" E to27° 06' 16" N, 72 °19' 38"E	210-240	12.38	29.45	299.2
Barmer	25° 11' 50" N, 71 ° 43' 19" E to25° 27' 13" N, 71 ° 23' 63" E	53-83	13.27	29.76	346.15
Nagaur	26° 35' 36" N, 74 ° 20' 97" E to27° 04' 85" N, 73 ° 49' 29" E	289-392	12.02	28.81	495.65
Jalore	25° 00' 80" N, 72 ° 23' 76" E to25° 23' 10" N, 72 ° 30' 73" E	125-218	13.46	29.86	533.4
Pali	25° 44' 37" N, 73 ° 19' 78" E to26° 05' 80" N, 74 ° 05' 77" E	299-350	12.31	29.03	639.3
Ajmer	26° 03' 29" N, 74 ° 46' 10" E to26° 21' 28" N, 74 ° 37' 61" E	425-472	12.52	28.81	529.85
Banaskantha	24° 33' 46" N, 71 ° 73' 76" E to24° 53' 39" N, 72 ° 05' 66" E	98-189	13.94	30.07	623.65
Patan	23° 50' 30" N, 72 ° 10' 06" E to24° 06' 34" N, 71 ° 78' 92" E	36-76	15.01	30.69	640.15
Kuchchh	23° 34' 69" N, 69 ° 77' 29" E to24° 18' 62" N, 71 ° 11' 00" E	85-112	16.63	30.59	450.05
Surendranagar	22° 45' 06" N, 71 ° 65' 63" E to23° 28' 71" N, 71 ° 79' 34" E	83-103	16.31	31.73	517.15
Amreli	21° 78' 32" N, 71 ° 33'85" E to22° 01'18" N, 71 ° 88' 54" E	110-124	16.35	33.04	520.22

Source: Climate data by National Innovations in Climate Resilient Agriculture, (NICRA); ICAR-Central Research Institute for Dry Land Agriculture, Hyderabad;*Temperature and rainfall during cropping season.

number of 5 ridges were present in all samples but higher order varied with locations, non-specifically. The seed shape did not bear any significant association with location and it was found to be oval to oblong irrespective of AESR's. On mass basis, test weight ranged between 3.02-4.38 g, of which Ajmer sample accounted the highest and Jalore the least.

Essential oil (EO) yield

Yield of essential oil recorded through hydro-distillation of cumin seeds from various districts is presented in Fig 1. The data reveals that the overall yield of EO lies between 28.4-39.1 g/kg, higher EO content was recorded in the cumin samples from Nagaur (38.5 ± 0.37), followed by Jaiselmer (37.4 ± 0.31) and least in Ajmer (Rajasthan) (28.6 ± 0.27) whereas, samples from Patan district, Gujarat, possessed highest EO content (39.1± 0.17) with least values in Amreli district (28.4 ±1.08). The statistical analysis indicated that there was significant difference in the EO content of cumin seeds from various districts in Rajasthan and Gujarat. Chemical composition of cumin seed oil has also been reported elsewhere by some researchers (Agrawal 1996 and Sharma *et al.* 2016). The variation in cumin essential oil content depends upon the stage of harvest and other climatic factors which control the oil synthesis in the plants (Moghaddam *et al.* 2015). The EO content in cumin from China was reported to be 3.8% (Li and Jiang 2004) whereas in cumin from Tunisia and Iran it was reported to be 1.6% and 1.4 to 2.2% respectively (Rebey *et al.* 2012). The variation in essential oil again depends on various factors viz. cultivar used, package of practices, agro-ecology, harvesting stage, drying and storage methods etc. (Burt 2004). Plant ontogeny has very significant influence on oil yield which varies place to place and plant species (Ozcan and Chalchat 2006). Correlation between volatile oil constituents and wilt resistance in cumin was reported by Agrawal (1996). Ongoing study was conducted on farmer's samples but an assumption of common cultivar is not denied herewith as farmer's information in most of the cases declared planting of Gujarat Cumin-4 variety of cumin.

Secondary metabolite total phenol and flavonoid content

Flavonoids, phenolic acids and polyphenols present in plant and their products contribute effectively towards antioxidant properties (Mishra *et al.* 2015 and Allahghadri *et al.* 2010). Antioxidants promote inhibition of oxidation in functional food ingredients and its activity can be studied through different mechanisms (Shahidi and Ambigaipalan 2015). Synthesis of EO and its components increases significantly under abiotic stress, which prervents oxidative modification of lipoproteins in plant cells (Bettaieb *et al.* 2010). Phenolic compounds have high reduction-oxidation properties, which play a crucial role in trapping and neutralising free radicals, or decomposing peroxides (Miguel 2010).

Total flavonoid content in methanolic extract of cumin seeds collected from different districts are presented in Table 2. The average flavonoid content (mg QE/gm seeds) was highest in Nagaur (39.72), followed by Amreli (36.03) and lowest in Ajmer district (23.71), whereas the phenol content (mg GAE/g seeds) was maximum in Jalore (73.61), followed by Nagaur (63.77), Jodhpur (58.93) and least in

Table 2 Cumin seed morphology, essential oil, phenol and flavonoid content

District	Colour (Munsell)	Seed ridges	Shape	Moisture content (%)	Test weight (1000 seeds) (g)	Essential oil content (g/kg)	Total phenolic content (mg GAE/g)	Total flavonoid content (mg QE/g)
Jodhpur	Dark brown to greyish brown	5-6	oval to oblong	7.85	3.69	34.1 ± 0.74	58.93	31.31
Jaisalmer	Very dark grey to dark grey	5-8	oval to oblong	8.05	4.05	37.4 ± 0.31	43.02	32.76
Barmer	Dark brown to dark greyish brown	5-7	oblong	7.67	3.57	31.7 ± 0.69	58.41	31.75
Nagaur	Very dark greyish brown to yellowish brown	5-6	oval to oblong	8.12	4.07	38.5 ± 0.37	63.77	39.72
Jalore	Very dark greyish brown to dark yellowish brown	5-7	oval to oblong	7.33	3.02	34.9 ± 0.59	73.64	34.88
Pali	Dark brown to brown	5-8	oval	7.81	3.72	33.6 ± 0.15	49.97	34.44
Ajmer	Very dark greyish brown to dark greyish brown	5-7	oblong	8.16	4.38	28.6 ± 0.27	48.94	23.71
Banaskantha	Very dark greyish brown to dark greyish brown	5-7	oblong	8.12	4.24	33.9 ± 0.38	43.64	31.08
Surendra nagar	Very dark greyish brown to greyish brown	5-7	oval to oblong	7.76	3.38	35.2 ± 0.27	45.30	32.30
Amreli	Very dark greyish brown to dark greyish brown	5-7	oval	7.85	3.50	28.4 ±1.08	41.50	36.03
Kuchchh	Dark yellowish brown to brown	5-6	oblong	7.92	3.84	35.9 ± 0.30	54.60	23.78
Patan	Very dark greyish brown to dark greyish brown	5-7	oval to oblong	7.51	3.13	39.1± 0.17	53.45	28.83

Table 3 Proximate composition of cumin seed samples

District	Cu	Zn	Fe	Mn	Ca	Mg	S	N	P	K	Carbohydrates	Protein
	(ppm)						(%)					
Jodhpur	16.2	486.8	425.0	48.9	1.34	3.26	0.10	3.50	0.37	1.77	15.86	21.89
Jaisalmer	16.2	448.2	612.5	54.0	1.05	3.28	0.13	3.08	0.29	1.72	19.94	19.26
Barmer	14.9	428.9	312.5	46.3	1.86	1.74	0.10	3.09	0.47	1.78	17.16	19.33
Nagaur	16.2	438.6	287.5	46.3	1.58	1.42	0.14	3.09	0.39	1.59	16.35	19.30
Jalore	16.8	455.4	525.0	77.2	1.53	2.27	0.12	3.15	0.40	2.50	28.88	19.71
Pali	22.4	448.2	337.5	38.6	1.40	3.20	0.16	3.13	0.55	2.65	26.47	19.58
Ajmer	19.9	472.3	437.5	46.3	1.24	2.83	0.15	2.96	0.59	2.26	24.15	18.52
Banaskantha	13.7	443.4	275.0	84.9	1.27	2.87	0.11	3.37	0.47	2.14	19.59	21.08
Surendra nagar	13.1	455.4	337.5	57.9	1.45	3.15	0.13	3.32	0.29	2.01	20.80	20.75
Amreli	14.9	469.9	337.5	99.3	1.18	3.42	0.11	3.49	0.46	2.53	19.33	21.80
Kuchchh	14.9	433.7	375.0	73.3	1.29	3.61	0.14	3.11	0.48	2.22	23.63	19.42
Radhanpur	11.2	419.3	487.5	69.4	1.08	1.72	0.15	3.09	0.52	2.60	23.38	19.32
Mean	15.9	450.0	395.8	61.9	1.36	2.73	0.13	3.20	0.44	2.15	21.30	20.00
Range	11.2-22.4	419-486	275-612	38-99	1.05-1.86	1.42-3.61	0.10-0.15	2.96-3.49	0.29-0.59	1.59-2.70	15.86-28.88	19.30-21.89

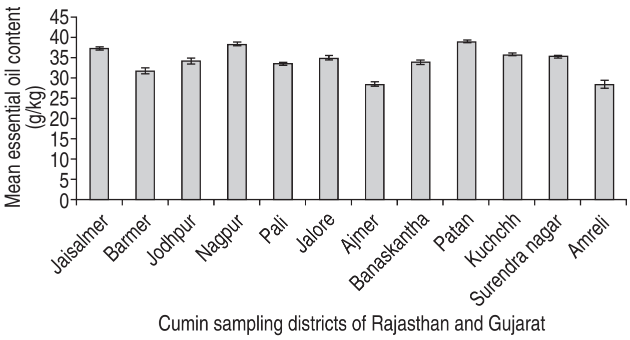

Fig 1 Essential oil content in cumin seeds from various districts

Amreli district (41.50). Varying amount of total phenolic content has been reported by various authors, Moghaddam *et al.* (2015) reported 25.52-40.0 mg/g phenols in E.O. at different stages of cumin crop. Agrawal (1996) reported phenolic and flavonoid content in various genotypes of cumin from India, that ranged between 70.4-92.4 mg GAE/ g seeds and 41.1-55.1 mg QE/g seeds respectively, which are in conformity with our findings. The variation in antioxidant components, viz. phenols and flavonoids within the samples and among the samples from various districts of the arid and semiarid cumin growing areas in the present investigation is a result of ecological and physiological conditions, harvest time and seed maturity. These variations affect the status, quantity and quality of secondary metabolites under study (Ozcan and Chalchat 2006, De Abreu and Mazzafera 2005). The methodology of extraction also has bearing on these components (Rebey *et al.* 2012). The occurrence of these secondary metabolite compounds in the seeds certainly depends upon other biotic and abiotic factors beside just agro-ecological location and weather parameters.

Proximate analysis of cumin seeds

Cumin can be a potential source of mineral supplement, the analytical values for various elements in cumin from Rajasthan and Gujarat has been presented in Table 3. The range and mean value for the elements Cu, Fe, Zn, Mn, Ca and Mg (ppm) and S, N, P and K (%) are 11.2-22.4 (15.9); 419-486 (450); 275-612 (395.8); 38-99 (61.9); 1.05-1.86 (1.36); 1.42-3.61 (2.73); 0.10-0.15 (0.13); 2.96-3.49 (3.20); 0.29-0.59 (0.44) and 1.59-2.70 (2.15) respectively. Among the micronutrients a decreasing trend was observed for Zn>Fe>Mn>Cu. Higher values of Fe content was observed in the seeds from Jaisalmer and Jalore. Among the secondary nutrients the decreasing trendsof Mg>Ca>S was recorded. The carbohydrates content and total protein content ranged from 15.86-28.88 (21.30) and 19.30-21.89 (20.0) per cent respectively. The findings of present investigation are approximately similar for some elements reported by Li and Jiang (2004).

The data in this study revealed that AESRs have preponderant effect on cumin quality. The variation in physical and nutrient composition of cumin seed collected from arid and semi-arid AESRs of India is not too much significant due to varietal similarity. However, essential oil content varied significantly within as well as between the AESRs. The total phenols and flavonoid content also varied with location, but little variation was recorded with respected to total carbohydrates, proteins and mineral composition of cumin seed samples from different districts located in separate AESR. Variability in physical and chemical composition depends on several factors including climate, geographical location, soil, part of the plant, method used to obtain essential oil etc. The variability in quality characteristics of cumin may be useful in promoting trade and export of cumin through geographical indicator (GI) in this era of intellectual property rights.

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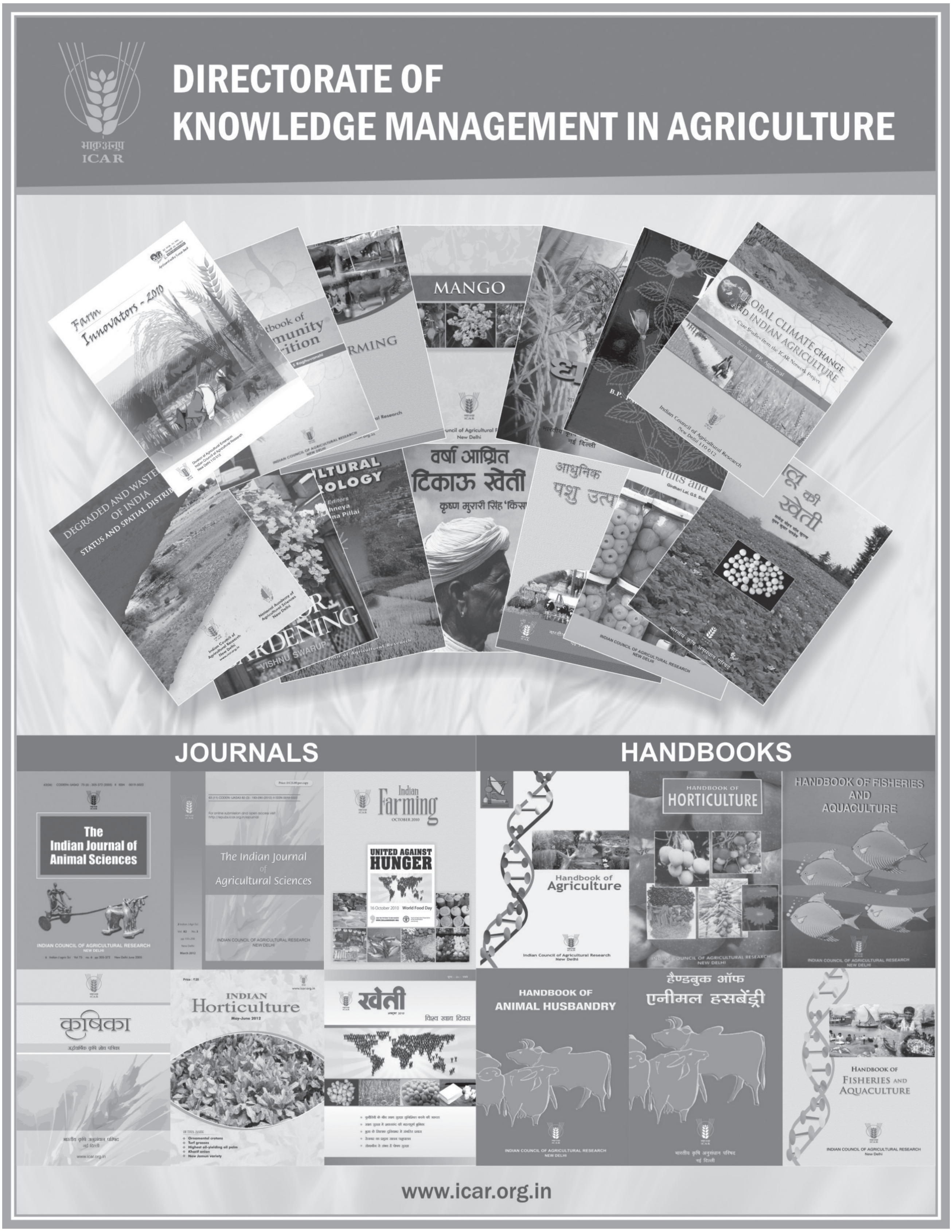

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