

Harnessing digital innovations to transform production and value chains in the spice industry

Digitalization is transforming the spice industry, offering innovative solutions for production, supply chain optimization, and marketing. India, the largest producer and exporter of spices, is at the forefront of integrating emerging digital technologies such as sensors, drones, and mobile applications to enhance sustainability and precision in spice cultivation. Technologies like the Spice Var database, decision support tools, and AI-driven quality assessments are improving farming practices, boosting productivity, and ensuring food safety. Additionally, blockchain technology and e-auction platforms like eSpice Bazaar and SPIISRY are streamlining trade and traceability, providing transparency in the spice supply chain. The adoption of these digital tools not only improves efficiency but also promotes eco-friendly and sustainable farming practices, benefiting producers, consumers, and the environment. As the industry continues to evolve, digital innovation will play a crucial role in maintaining the heritage of spices while adapting to modern market demands.

DIGITALIZATION has become an integral part of our daily lives worldwide, and it is increasingly crucial in production and supply chain of spices. Emerging trends involve the use of sensors, digital tools, and online platforms to enhance transparency and sustainability of the spices production.

Spices are high value and low volume, export-oriented commodities, commonly used for flavouring and seasoning of food and beverages. India is the world's largest producer, consumer, and exporter of spices; the country produces about 75 of the 109 varieties listed by the International Organization for Standardization (ISO) and accounts for half of the global trading in spices. Growing demand from the emerging segment of nutraceuticals is driving the global consumption of Indian spices further at a time when the country is straining to meet the needs of the traditional food sector. The cultivation of spices in India is in an area of 4.76 million ha with a production of 11.80 million tonnes during 2023-24. India's share in spices export at global level is 1.42 million metric tonnes, accounting for US \$ 4.46 billion (Spices Board, 2024).

Precision in production

Precise methods are employed for fertilisation more efficiently and to reduce the use of pesticides and irrigation. Advisory services such as digital support tools and automatic

weather stations are increasingly being adopted. As many advanced technologies require small producers to make large investments, low-cost smartphone applications are being developed in spices- and herb-producing countries.

Application of drones

To promote drone technology for spraying purposes and precision agriculture, demonstrations have been conducted at both the ICAR-Indian Institute of Spices Research and the ICAR-National Research Centre on Seed Spices. These demonstrations highlighted how drones improve efficiency, reduce labour costs, and enhance crop management through precise application of inputs (plant protection chemicals, nutrients etc).

The unmanned aerial vehicle (UAV) platform is a

Var.	Crop	Var.	Region	Var.
1001	Black pepper	1001	India	1001
1002	Black pepper	1002	India	1002
1003	Black pepper	1003	India	1003
1004	Black pepper	1004	India	1004
1005	Black pepper	1005	India	1005
1006	Black pepper	1006	India	1006
1007	Black pepper	1007	India	1007
1008	Black pepper	1008	India	1008
1009	Black pepper	1009	India	1009
1010	Black pepper	1010	India	1010
1011	Black pepper	1011	India	1011
1012	Black pepper	1012	India	1012
1013	Black pepper	1013	India	1013
1014	Black pepper	1014	India	1014
1015	Black pepper	1015	India	1015
1016	Black pepper	1016	India	1016
1017	Black pepper	1017	India	1017
1018	Black pepper	1018	India	1018
1019	Black pepper	1019	India	1019
1020	Black pepper	1020	India	1020
1021	Black pepper	1021	India	1021
1022	Black pepper	1022	India	1022
1023	Black pepper	1023	India	1023
1024	Black pepper	1024	India	1024
1025	Black pepper	1025	India	1025
1026	Black pepper	1026	India	1026
1027	Black pepper	1027	India	1027
1028	Black pepper	1028	India	1028
1029	Black pepper	1029	India	1029
1030	Black pepper	1030	India	1030
1031	Black pepper	1031	India	1031
1032	Black pepper	1032	India	1032
1033	Black pepper	1033	India	1033
1034	Black pepper	1034	India	1034
1035	Black pepper	1035	India	1035
1036	Black pepper	1036	India	1036
1037	Black pepper	1037	India	1037
1038	Black pepper	1038	India	1038
1039	Black pepper	1039	India	1039
1040	Black pepper	1040	India	1040
1041	Black pepper	1041	India	1041
1042	Black pepper	1042	India	1042
1043	Black pepper	1043	India	1043
1044	Black pepper	1044	India	1044
1045	Black pepper	1045	India	1045
1046	Black pepper	1046	India	1046
1047	Black pepper	1047	India	1047
1048	Black pepper	1048	India	1048
1049	Black pepper	1049	India	1049
1050	Black pepper	1050	India	1050
1051	Black pepper	1051	India	1051
1052	Black pepper	1052	India	1052
1053	Black pepper	1053	India	1053
1054	Black pepper	1054	India	1054
1055	Black pepper	1055	India	1055
1056	Black pepper	1056	India	1056
1057	Black pepper	1057	India	1057
1058	Black pepper	1058	India	1058
1059	Black pepper	1059	India	1059
1060	Black pepper	1060	India	1060
1061	Black pepper	1061	India	1061
1062	Black pepper	1062	India	1062
1063	Black pepper	1063	India	1063
1064	Black pepper	1064	India	1064
1065	Black pepper	1065	India	1065
1066	Black pepper	1066	India	1066
1067	Black pepper	1067	India	1067
1068	Black pepper	1068	India	1068
1069	Black pepper	1069	India	1069
1070	Black pepper	1070	India	1070
1071	Black pepper	1071	India	1071
1072	Black pepper	1072	India	1072
1073	Black pepper	1073	India	1073
1074	Black pepper	1074	India	1074
1075	Black pepper	1075	India	1075
1076	Black pepper	1076	India	1076
1077	Black pepper	1077	India	1077
1078	Black pepper	1078	India	1078
1079	Black pepper	1079	India	1079
1080	Black pepper	1080	India	1080
1081	Black pepper	1081	India	1081
1082	Black pepper	1082	India	1082
1083	Black pepper	1083	India	1083
1084	Black pepper	1084	India	1084
1085	Black pepper	1085	India	1085
1086	Black pepper	1086	India	1086
1087	Black pepper	1087	India	1087
1088	Black pepper	1088	India	1088
1089	Black pepper	1089	India	1089
1090	Black pepper	1090	India	1090
1091	Black pepper	1091	India	1091
1092	Black pepper	1092	India	1092
1093	Black pepper	1093	India	1093
1094	Black pepper	1094	India	1094
1095	Black pepper	1095	India	1095
1096	Black pepper	1096	India	1096
1097	Black pepper	1097	India	1097
1098	Black pepper	1098	India	1098
1099	Black pepper	1099	India	1099
1100	Black pepper	1100	India	1100

SpicesVar database

high throughput phenotyping technology that successfully estimates the growth performance, physiological changes, and yield. A study conducted at Thailand, successfully developed an approach to estimate the above and below ground traits of turmeric plants using the UAV platforms and also verified the superior accession by curcuminoids yield.

Digital tools promote sustainable farming practices and educate farmers about the eco-friendly technologies.

SpicesVar

SpicesVar is ICAR-AICRPS's database on the performance of spice varieties in India. Spices Var is also a platform for the exchange of know-how and a tool to safeguard, retrieve, and exchange information related to spices. Information can be retrieved regarding three groups of spice crops: major, tree and seed spices. The database has a primary function, which is data retrieval. Access to and use of the database are free. It is a powerful search engine for easy retrieval and comparison of information. It is also a template for educational purposes and a gateway to spice knowledge and statistics.

SpicesVar addresses the needs of producers, the public, and spice research centres for information management related to spice crop cultivars in different agro-climatic environments and allows users to identify cultivars adapted to their specific requirements and environment. Scientists from spices research institutes and universities reviewed the database and provided



valuable comments and suggestions for its design and improvement. (<http://14.139.189.29/SpicesVar>).

Smartphone applications

ICAR-Indian Institute of Spices Research has developed and launched a mobile app (black pepper, cardamom, ginger and turmeric) for the benefit of farmers who is interested in spices cultivation. It is a simple, user-friendly application providing authentic and scientific information on spices cultivation. It is available in Google Play Store and can be freely downloaded in any android devices. Currently it is available in English and Hindi and soon other versions will be made available.

Decision support tools

The range of decision support tools is extensive and includes software solutions for farmers (such as bookkeeping, planning and agricultural science), software connected to weather stations used to plan plant protection, determination of the best time to harvest, and many others.

Spice FeRT

ICAR-IISR has developed a soil test-based fertilizer recommendation for targeted yield of spices (Spice FeRT). For obtaining a particular yield, the plant takes up a definite amount of major nutrients. Once this requirement is known, the fertilizer requirement can be estimated taking into consideration the contribution from soil available nutrients and fertilizer use efficiency levels. This software is for getting fertilizer recommendations for the targeted yield based on the factors like initial soil fertility, nutrient required per unit yield (NR), contribution of nutrient from soil (CS) and contribution from fertilizer (CF) that were standardized, validated and recommended for major spice crops, viz. black pepper, ginger, turmeric and cardamom. Through this targeted nutrient supply, one can avoid imbalance of nutrients in soil, improve fertilizer use-efficiency and increase yield as compared to the blanket recommendation (<http://14.139.189.27/soil/turmeric.html>).

Card SiS and CardSApp

Indian Cardamom Research Institute (ICRI), Spices Board developed a GIS based spatial interpolation of soil nutrients of cardamom in collaboration with Rubber Research Institute of India (CardSiS, <https://www.indianspices.com/research/slides.html>). The web based fertiliser recommendation was developed based on interpolated soil fertility data in collaboration with Digital University, Kerala, overlaying different soil fertility parameters and soil depth following the guidelines of soil test-based fertiliser recommendations by ICRI.

Presently, the CardSApp (<https://cardsapp.spicesboard.org.in>) is applicable to cardamom growing

Spice FeRT software



areas in ten villages for Idukki, Kerala. In the second phase of the project, CardSApp will cover the other cardamom growing regions of Idukki, Tamil Nadu and Karnataka.

Geostatistical analyst of ArcGIS software was used for generating soil nutrient maps using Inverse Distance Weighted Algorithm. Spatial interpolation maps were prepared for 12 nutrients like organic carbon (OC), soil pH, available potassium (K), available calcium (Ca), available magnesium (Mg), available boron (B), available copper (Cu), available iron (Fe), available manganese (Mn), available phosphorous (P), available sulphur (S) and available zinc (Zn). Further, village-wise spatial variability of soil nutrient maps was prepared in the Geotiff format with cell size of 30 m.

Processing and digital innovations

New technologies, equipment and databases enable precise measurement of the main quality parameters for certain products. This improves transparency and control over quality and food safety issues. In the spices and herbs sector, this involves monitoring parameters such as moisture, density and seed size, as well as controlling contamination with foreign bodies. Process automation and artificial intelligence are also key trends. Advanced quality assessment can be performed by an electronic nose – a sensing device that detects odours and flavours. For example, the leading spice company uses artificial intelligence to develop new flavours. A leading laboratory testing companies use next generation sequencing to establish the authenticity of products. This DNA fingerprint database contains unique identifying characteristics (the “fingerprints”) of foodstuffs and makes it possible to obtain proof of authenticity, which was not previously available.

The European Union has developed a tool to ensure the flow of information and a quick response when risks to public health are detected in the food chain. This tool is called the Rapid Alert System for Food and Feed (RASFF). Food inspectors in all EU member states collect information about the reasons why different food products have been rejected by the market and send those data to RASFF (<https://webgate.ec.europa.eu/rasff-window/screen/search>).

Blockchain technology and traceability

The blockchain technology is increasingly being used to reduce the costs of intermediaries. Blockchain systems allow each stakeholder in the supply chain to view the

progress of goods throughout the supply chain, monitor the container movement in real time, and see the status of the customs documents. In addition to tracking the goods, blockchain technology can be used to encrypt important documentation (e.g. regarding quantities or prices and contracts). An example of a successful use of blockchain technology is for the sourcing of spices and herbs (<https://www.verstegen.co.uk/verstegen-sustainability/blockchain>). By scanning the QR code on a package of nutmeg it is possible to learn more about the place of origin and to see which farmer has grown that particular packaged spice.

Recently, the Indian Spice Board has signed a memorandum of understanding with the United Nations Development Programme (UNDP) Accelerator Labs to build a blockchain-based traceability interface for Indian spices. The project will be piloted with more than three thousand chilli and turmeric farmers in select districts of Andhra Pradesh.

Digital innovations in marketing

e-Auction Centres of Cardamom: E-auction of cardamom plays a key role in the primary sale of the small cardamom in India under the provisions of the Cardamom Licensing & Marketing Rules 1987 framed in accordance with Spices Board Act 1986. In order to bring the transparency and functional convenience in trading operations of cardamom, Spices Board had introduced E-auction facility at its auction centres in Bodinayakanur, Tamil Nadu and Puttady, Kerala in 2007, replacing the traditional outcry system. Spices Board has upgraded the e-auction system to Cloud based live E-auction in 2021 to conduct e-auction of Cardamom (small) simultaneously from the two auction centres. Similarly, the Spices Board of India has also developed a specific spice trade platform – eSpice Bazaar (<http://espicebazaar.in/>). This platform serves not only as a simple trade tool, but it includes many support functions for different spices in the supply chain. Stakeholders Agricultural and Processed Food Products Export Development Authority (APEDA) has launched the Agri Exchange platform (<https://agriexchange.apeda.gov.in/>) where suppliers and buyers can search for offers in specific spice categories.

Market research

Several marketing research companies regularly collect extremely large data sets related to retail sales of food items to identify consumer behaviour and trends. These companies sell data to commercial companies to help them innovate and make better marketing decisions. However, for most small and medium-sized companies, the large data sets of leading data providers are too expensive for daily use. The commodity market is fast becoming one of the most popular segments of the financial market. Commodity trading involves purchasing and selling derivative contracts such as futures and options. The primary commodity exchange in spices is NCDEX. National Commodity & Derivatives Exchange Limited (NCDEX / the Exchange) is a professionally managed on-line, commodity Exchange, with diverse product offerings setting a benchmark for both agriculture and non-agri commodities derivatives segment. Currently,



the exchange offers derivative contracts in spices for black turmeric, coriander, cumin and cumin mini.

SPIISRY (<https://spiisry.in/>), the online sales outlet of ICAR-Indian Institute of Spices Research, gives fresh hope to farmers and start-ups. SPIISRY' works as a linkage point for farmers, startups, and customers to ensure mutual benefits to all stakeholders. Small spice processors can also leverage e-commerce solutions in various ways. A startup entrepreneur, backed by ICAR-IISR, successfully utilizes web-based marketing for spices and spices blends (<https://www.diasporaco.com/?view=sl-7C27D6AC>).

SUMMARY

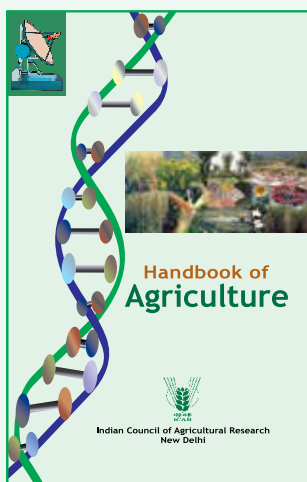
Digital innovation in the spice industry is transforming the traditional practices, enhancing efficiency, and opening new avenues for growth. From precision farming techniques and supply chain optimization to e-commerce platforms, technology is enabling producers to meet

the evolving demands of the market. As data analytics and AI continue to shape the landscape, stakeholders can leverage insights to improve quality, reduce waste, and ensure sustainability. Ultimately, embracing digital innovation not only benefits businesses but also enriches the consumer experience, fostering a deeper appreciation for spices in a rapidly changing world. The future of spices is not just about flavour; it's about smart, sustainable, and connected practices that celebrate heritage while embracing modernity.

For further interaction, please write to:

Dr D. Prasath (Project Coordinator), ICAR-All India Coordinated Research Project on Spices, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala 673 012. *Corresponding author: Prasath.D@icar.gov.in

Handbook of Agriculture



The Handbook of Agriculture is one of the most popular publication of the ICAR with a wider readership. The present edition presents science-led developments in Indian agriculture, the ongoing research efforts at the national level and with some ideas on the shape of future agriculture. While information in some chapters such as Soil and water, Land utilization, field and forage crops has been updated with latest developments, many new topics such as the Environment, agrobiodiversity, Resource conservation technologies, IPM, Pesticides residues, Seed production technologies, Energy in agriculture, informatics, Biotechnology, Intellectual Property Rights, Agricultural marketing and trading and Indigenous Technical Knowledge have been included in the present edition. For those who take intelligent interest in agriculture – and their number is increasing fast – the present edition would serve as a useful book.

TECHNICAL SPECIFICATIONS

Size	:	Royal Octavo (16 cm x 24 cm)
No. of pages	:	i-xii + 1620
Price	:	₹ 2000
Postage	:	₹ 200
ISBN No.	:	978-81-7164-096-6

For obtaining copies:

Business Manager

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel: 011-25843657, Fax: 09-11-25841282; E-mail: bmicar@gmail.com

SCAN QR Code to
Purchase Online

